2018 Kansas Integrated Water Quality Assessment

Republican River in Cloud County, KS – October 2017

March 30, 2018
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EXECUTIVE SUMMARY

This report, the Kansas Integrated Water Quality Assessment (2018), was prepared by the Kansas Department of Health and Environment (KDHE) in response to water quality reporting requirements contained in sections 303(d), 305(b), and 314(a) of the federal Clean Water Act (CWA). Section 303(d) calls for the development of a list of waterbodies currently failing to meet established water quality standards, whereas sections 305(b) and 314(a) require information concerning the overall status of the state's surface waters and the programs responsible for water quality monitoring and pollution abatement.

The Kansas 2018 list of impaired waters (*i.e.,* 303(d) list) is included as an appendix to this report. This list is based primarily on data collected by the KDHE targeted surface water monitoring programs and secondarily on information obtained from outside sources. For this assessment, watersheds containing targeted stream chemistry and/or stream biological monitoring stations represented the assessment units for flowing waters. Monitored lakes and wetlands represented the assessment units for standing waterbodies. The state's 2018 303(d) list identifies 498 station/pollutant combinations of water quality impairment on lakes, wetlands, and stream systems (watersheds), encompassing 2,437 stream segment/pollutant combinations, and needing the development of Total Maximum Daily Load plans (TMDLs) to address the offending pollutants. The 2018 list also identifies 480 station/pollutant combinations of waters that were previously cited as impaired in prior lists but now meet water quality standards, with 19 of these being new in 2018.

Requirements related to Section 305(b) were addressed, in part, using data obtained through a stream monitoring program implemented in 2006. This program employs a probabilistic survey design to estimate the stream mileage supporting those uses recognized in section 101(a) of the CWA: aquatic life support, food procurement, and contact recreation. The program's target population for monitoring and assessment included all classified streams that contained water during the summer low-flow periods of 2011-2015. Owing largely to climate variation during this assessment window, only about 64% of the state's classified stream mileage was represented in the target population for assessment. Lake and wetland assessments for Section 305(b) as well as Section 314 reporting requirements were addressed using data from the targeted lake and wetland program, which uses a near-census approach in its monitoring.

Monitoring data obtained during this reporting cycle indicated that approximately 16% of the state's designated stream mileage fully supported all three section 101(a) uses, whereas 84% was impaired for one or more uses. Aquatic life, contact recreation, and food procurement uses were supported, respectively, in 33%, 80%, and 66% of the stream miles designated for these uses. The two major causes or observed effects that demonstrated non-support for streams were suboptimal aquatic macroinvertebrate community metrics, which is an indicator of aquatic life support, and mercury in fish tissue, which is an indicator of food procurement use. Presence of contaminants such as bacteria, metals, and pesticides in water comprised a third category of causes. The most widespread discernible sources responsible for use impairments and/or pollutant loadings were generalized anthropogenic influences (*e.g.,* erosion and sedimentation, atmospheric deposition of contaminants), followed by agriculture (both crop and livestock production), and other sources (including natural sources and unknown sources). Urban influences (both point and nonpoint sources) were less widespread, an unsurprising result given the ratio of urban to rural land use in Kansas.

Approximately 3.5% of the assessed lake acreage fully supported all designated uses, whereas over 96% was impaired for one or more designated uses. Approximately 63% of the assessed lake acreage exhibited no recent change in trophic condition, less than 1% exhibited some improvement in trophic state, and 34% experienced a measurable deterioration in trophic state (with 3% unknown). Approximately 73% of wetland acreage was assessed. Of this population, less than 1% fully supported aquatic life and recreational uses. Major causes of impairment in both lakes and wetlands included nutrient enrichment, siltation and turbidity, and zebra mussel (*Dreissena polymorpha*) infestations; flow alterations and presence of sulfates also affected wetlands. Agriculture, hydromodification, natural sources, and municipal point sources were the primary sources of these impairments.

Kansas experienced some flooding in 2010 followed by significant and extended statewide droughts in 2011-2013; 2014 marked the beginning of drought recovery. The combined effects of these dramatic weather-related events doubtless exacerbated many of the water quality impairments documented in the past decade.

PART A: INTRODUCTION

Purpose

This document fulfills specific water quality reporting requirements placed on the State of Kansas by sections 303(d), 305(b), and 314(a) of the Federal Clean Water Act. Sections 305(b) and 314(a) require a summary of the status of the state's surface waters. Section 303(d) calls for development of a list of waterbodies currently failing to meet established water quality standards, which are regarded collectively as "impaired waters." Kansas is required under the CWA to take actions that improve the condition of impaired waters. These actions may include the development and implementation of TMDLs, water quality based permit requirements, and/or nonpoint source (NPS) pollution control measures. This report presents an integrated response to the requirements of sections 303(d), 305(b), and 314(a) and contains information relevant to upcoming water quality planning, monitoring, permitting, and pollution abatement initiatives in the state.

General Assessment Approach

KDHE administers several programs that collectively satisfy the environmental monitoring and reporting requirements of the CWA (KDHE 2010). These programs also provide the technical data needed to respond to existing and emerging water pollution problems. Departmental monitoring operations currently focus on the condition of the state's surface waters (rather than groundwater) and involve two different but complementary conceptual approaches. The first involves a targeted survey design that focuses on selected lakes, wetlands, and stream reaches. The second approach involves a probabilistic survey design that assesses randomly chosen stream reaches and extrapolates the monitoring results to the entire population of classified streams in the state. Targeted monitoring operations accommodate the development and refinement of the Kansas 303(d) list, whereas both targeted and probabilistic data are used to meet section 305(b) and 314(a) Clean Lakes Program reporting requirements.

Within KDHE, activities related to sections 305(b), 314(a), and 303(d) sections of the CWA are performed by the Watershed Planning, Monitoring, and Assessment Section of the Bureau of Water (BOW). Portions of this report addressing sections 305(b) and 314(a) characterize the overall condition of the state's streams, lakes, and wetlands, including both water quality and the prevalence of bioaccumulative contaminants in fish. They also describe the major monitoring networks and regulatory programs involved in the tracking, management, and abatement of surface water pollution. The 303(d) analysis differs from the 305(b) and 314(a) assessments in terms of statistical approach and monitoring period of interest. Moreover, under the provisions of the CWA, the 303(d) list is subjected to public comment and review as well as approval by the U.S. Environmental Protection Agency (EPA).

Organization of Report

The remainder of this report is divided into several major parts. Part B contains background information on surface water resources within the state, describes the governmental programs primarily responsible for improving water quality, considers the overall costs and benefits of water pollution control, and summarizes several important water quality issues facing Kansas. Part C discusses the various water quality monitoring programs administered by KDHE, the diagnostic criteria and statistical methods employed in the 303(d) and 305(b) analyses, and the major findings stemming from these analyses. Part D summarizes the current status of groundwater quality monitoring efforts in Kansas. Finally, Part E describes the measures taken by KDHE to comply with the public participation provisions of the CWA, as related to the development of the 303(d) list. Technical appendices to this report provide additional information on KDHE's water quality monitoring programs and the results of the most recent assessments. Specifically, **Appendix A** identifies the individual water chemistry and fish tissue parameters considered in the 2018 305(b) assessment, and **Appendix B** presents the most recently completed 303(d) list for Kansas.

PART B. BACKGROUND

Total Waters

Table 1 shows a summary of the waters of the State of Kansas (KDHE 2013), along with other geographic and demographic information. The waters on the Kansas Surface Water Register have received Use Attainability Analyses (UAAs) according to standard procedures (KDHE 2012).

Table 1. Geographic information on the total waters of Kansas

Topic	Value	Data Source
State population	2,853,118	U. S. Census Bureau, 2010 Census
State surface area in square miles	81,758.72	U. S. Census Bureau, 2010 Census
Number of major river basins	12	Dec 12, 2013 KSWR +
Total classified stream miles++	30,278	Dec 12, 2013 KSWR +
Total classified stream miles designated for food procurement ++	22,235	Dec 12, 2013 KSWR +
Number of lakes, reservoirs, and ponds (publicly owned or accessible)++	322	Dec 12, 2013 KSWR +
Acres of lakes, reservoirs, and ponds (publicly owned or accessible)++	190,445	Dec 12, 2013 KSWR +
Acres of freshwater wetlands (publicly owned or accessible)++	55,969	Dec 12, 2013 KSWR +

+ The functional stream geometry of the 2013 Kansas Surface Water Register (KSWR) is derived from the 1:24,000 scale National Hydrography Dataset (NHD), projected in Lambert Conformal Conic North America (Clarke 1866) and trimmed at state boundaries. Lake and wetland acreage estimates are based on adjusted areas of NHD polygons.
++ This includes classified waterbodies as published in the 2013 KSWR.

Water Pollution Control Program

I. POINT SOURCE POLLUTION CONTROL

The Kansas point source program was initiated in 1907 (K.S.A. 65-161 *et seq*.) and continues to be modified and expanded in response to ongoing amendments to the CWA. The federal regulations implementing this law are found in Title 40 of the Code of Federal Regulations. Federal water pollution control programs are designed to protect the navigable waters of the United States, whereas the Kansas Water Pollution Control KWPC Program is designed to protect all surface water and groundwater resources in the state by controlling discharges from municipal, federal, commercial, and industrial wastewater treatment facilities (WWTFs), permitted concentrated animal feeding operations (CAFOs), and urban and industrial stormwaters.

KDHE is authorized to administer federal and state laws governing the treatment, re-use, and discharge of wastewaters in Kansas. Specifically, the department is responsible for the development, public notice, issuance, and periodic review of water pollution control permits; the approval of engineering plans and specifications for WWTFs and sewage collection systems; the development of stormwater best management practices (BMPs); the establishment of pretreatment requirements for facilities in non-pretreatment program cities (EPA Region 7 administers pretreatment program cities); and the performance of treatment plant compliance reviews. The department also oversees the development and management of operator training and certification programs in Kansas. Non-overflowing WWTFs are regulated through the Kansas Water Pollution Control permitting system (K.S.A. 65-165). National Pollutant Discharge Elimination System (NPDES) permits are required for all discharging WWTFs, large, medium, and small Municipal Separate Stormwater Sewer Systems (MS4s), and large agricultural facilities (**Table 2**). Agricultural facilities primarily include CAFOs but also include other animal feeding operations as well as some livestock markets and livestock truck washes. Wastewaters generated by these treatment facilities and operations are subject to technological effluent limitations, effluent guideline limits, and the Kansas surface water quality standards. Individual permits normally are issued for a period of five years, and all are reviewed by KDHE prior to re-issuance. The state's WWTF permit compliance record for calendar years 2016 and 2017 is summarized in **Table 3.**

In addition to regulating wastewaters generated by these entities, the Kansas and federal programs have expanded into the area of stormwater pollution control. KDHE issues general permits for controlling stormwater runoff from construction and industrial sites, larger cities, and urbanized counties. Stormwater management plans have been implemented in 59 of the state's largest municipalities/counties/governmental entities and their surrounding areas to reduce the effects of stormwater runoff on receiving streams. In addition, stormwater pollution prevention plans are required for construction activities disturbing more than one acre of land and for certain classes of industries that conduct activities in which materials are exposed to rainfall. Industrial facilities with individual permits are also required to develop and implement stormwater pollution control plans as part of their individual permit requirements. Stormwater NPDES permits are normally issued for a period of five years (**Table 2**).

Table 2. Number of active KWPC and NPDES permits as of January 1, 2018

<table>
<tr><th colspan="2">Municipal and Commercial</th><th colspan="2">Industrial and Federal +</th><th colspan="2">Agricultural ++</th><th colspan="2">Stormwater</th></tr>
<tr><td>Mechanical Treatment Facilities (NPDES) +++</td><td>139</td><td rowspan="2">Industrial and Federal Discharging (NPDES) +++</td><td rowspan="2">373</td><td rowspan="2">Agricultural Federal (NPDES)</td><td rowspan="2">420</td><td rowspan="2">Municipal Separate Stormwater Sewer Systems (MS4) (NPDES)</td><td rowspan="2">64</td></tr>
<tr><td>Discharging Lagoons (NPDES) +++</td><td>347</td></tr>
<tr><td rowspan="2">Municipal and Commercial Non-discharging (KWPC)</td><td rowspan="2">412</td><td rowspan="2">Industrial and Federal Non-discharging (KWPC)</td><td rowspan="2">65</td><td>Agricultural State Permits (KWPC)</td><td>1317</td><td>Industrial Stormwater (NPDES)</td><td>850</td></tr>
<tr><td>Agricultural State Certificates (KWPC)</td><td>1554</td><td>Construction Stormwater (NPDES)</td><td>2860</td></tr>
<tr><td>Totals</td><td>898</td><td></td><td>438</td><td></td><td>3291</td><td></td><td>3774</td></tr>
</table>

KWPC = Kansas Water Pollution Control / NPDES = National Pollutant Discharge Elimination System
+ Tally does not include 59 industrial pretreatment facilities that discharge to municipal systems.
++ All agricultural facilities are nondischarging, but large facilities have combined Federal/State permits.
+++ Subject to monitoring by Compliance Monitoring Program and represented in Table 3.

Table 3. Permit compliance for discharging wastewater treatment facilities, 2016-2017

	Municipal and Commercial Facilities	Industrial and Federal Facilities
Total number of facilities	486	438
2015 absolute compliance+	92.9%	95.7%
2016 absolute compliance+	91.4%	96.1%

+ Absolute compliance means that a facility reported on all parameters specified in its NPDES permit and met all permit limits for the monitoring period (based on records submitted by the facility).

Over the past 13 years, a significant effort has been made to decrease nutrient (nitrogen and phosphorus) loadings to surface waters. In a document dated December 29, 2004, KDHE proposed and has since initiated a program whereby new and significantly upgraded mechanical wastewater treatment plants are required to construct and operate processes to reduce the amount of nitrogen and phosphorus in effluent discharges. As of January 1, 2018, more than half of the mechanical wastewater treatment plants that generate significant amounts of nitrogen and/or phosphorus have implemented or are building such nutrient reduction processes (Rod Geisler, Pers. Comm. 3/14/2018). The department uses several contractors to assist other large and major facilities to implement operational changes, if possible, or to provide reduction by chemical addition. Also, the department has several contracts to provide on-site training assistance to existing mechanical treatment facilities to improve nutrient removal processes. Investments in such training and technology have reduced nutrient loads.

II. NONPOINT SOURCE POLLUTION CONTROL

Nonpoint source pollution refers to the transport of natural and man-made pollutants by rainfall or snowmelt moving over and through the land surface and entering lakes, rivers, streams, wetlands, or groundwater. KDHE's Watershed Management Section (WMS) is responsible for developing the Kansas Nonpoint Source Management Plan, which provides a framework to coordinate agencies and organizations involved in nonpoint source related management activities. The WMS administers funding and coordinates programs designed to eliminate or minimize NPS pollution. To accomplish this goal, the section develops and reviews strategies, management plans, local environmental protection plans, and county environmental codes intended to control NPS pollution. These efforts are coordinated but are managed under several different programs.

The Watershed Restoration and Protection Strategy (WRAPS) program is one such effort administered by the Section; it offers a framework to engage citizens and other stakeholders in a teamwork environment aimed at protecting and restoring Kansas watersheds by developing and implementing 9 element watershed plans. These projects are supported in part by the CWA 319 funds.

The Drinking Water Protection Program is another program coordinated by the Section. It is designed to provide technical assistance to Public Water Supply Systems (PWSS) interested in writing and implementing a drinking water protection plan. Many PWSS are incorporated into Kansas WRAPS plans; however, those not covered by a WRAPS project are encouraged to complete drinking water protection plans.

The Local Environmental Protection Program (LEPP) provides technical assistance and support to county sanitarians in the implementation of local sanitary codes. Guidance provided by this program is largely related to private domestic onsite wastewater disposal systems, private domestic drinking water wells, and sanitary services, such as domestic septic disposal and land application. In conjunction with the work of county sanitarians throughout the state, LEPP program services complement a variety of water quality and public health efforts implemented by other local, state and federal agencies.

Finally, stormwater and NPS abatement projects have been supported through various funding mechanisms since 2009. A partnership between KDHE Watershed Management Section and KDHE Municipal Program used funds first from the American Recovery and Reinvestment Act (ARRA) of 2009, and then in 2010-2012 used part of the Green Project Reserve from the Kansas Water Pollution Control Revolving Fund. After 2012, Green Project Reserve funding was no longer available to the Watershed Management Section for NPS pollution projects. Thus, from 2013 to 2015, members of the Watershed Management Section staff pursued development and implementation of the Local Conservation Lending Program (LCLP). The LCLP makes funds available to local banks through a linked-deposit system; the banks then use these funds to offer low-interest loans to eligible borrowers for conservation projects aimed at protecting water quality in Kansas. The pilot phase began in late 2015.

Watershed Restoration and Protection Strategy

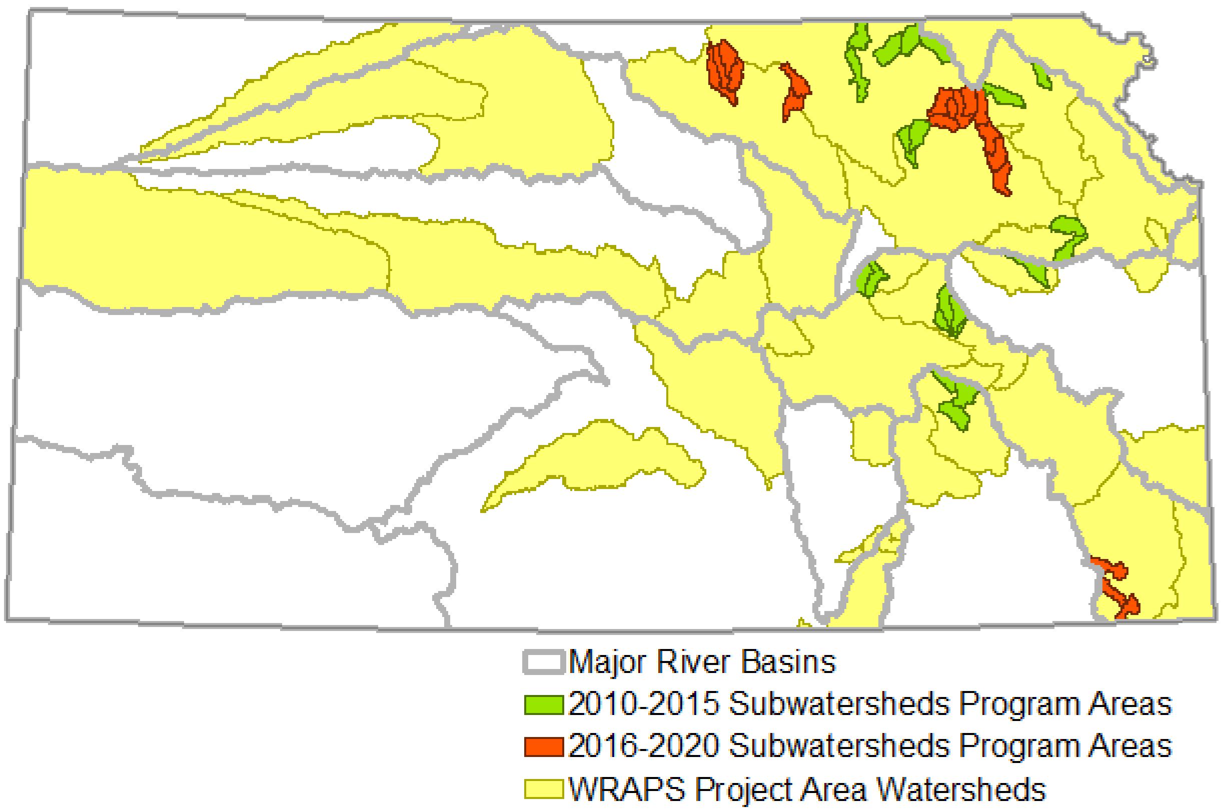
The WRAPS program is a voluntary targeted watershed-based program for controlling NPS pollution. This program is unique because the natural resource agencies of Kansas, with support from USEPA, aggressively seek citizen and stakeholder input and participation on watershed management and protection issues. This approach involves:

- Identifying watershed protection and restoration needs
- Establishing watershed protection and restoration goals
- Developing 9 element plans to achieve established goals
- Implementing fully developed plans

The 9 element watershed plans already implemented under WRAPS collectively serve and protect 45% of the state’s total land surface (24,576,154 acres). This includes most watersheds draining into large federal reservoirs (**Figure 1**). Annual investments in WRAPS projects total approximately $2.5 million (M). Of this amount, about $0.6 M is derived from State Water Plan funds and $1.9 M from CWA section 319 funds. Additional funds for Best Management Practices (BMPs) come from programs administered by the Kansas Department of Agriculture’s Division of Conservation as well as the Federal Farm Bill administered by the United States Department of Agriculture.

A KDHE initiative begun in 2010, the Subwatersheds Monitoring Program, tracks water quality changes over time in a selected set of HUC-12 subwatersheds as area stakeholders implement BMPs. It is a partnership between the Watershed Management Section and the Watershed Planning, Monitoring, and Assessment Section. Baseline data was obtained from the original 2011-2015 monitoring sites to ultimately be compared to future monitoring results after BMP implementation. In 2016, a new set of HUC-12 watersheds were identified (**Figure 1**) in three active WRAPS project areas, and monitoring in those subwatersheds are scheduled for 2016-2020.

Figure 1. Kansas WRAPS Projects as of December 2017



Drinking Water Protection Program

The Drinking Water Protection (DWP) Program is built on the principle that prevention often costs less than treatment. The program identifies drinking water source restoration and protection needs and provides technical assistance to Public Water Supply Systems (PWSS) to restore and protect water quality to meet drinking water standards. KDHE encourages PWSSs and their surrounding communities to complete voluntary DWP plans. Local stakeholders establish source water goals, corresponding action steps are created in the DWP plan, and the plan is implemented and monitored.

DWP plans are built on data from Source Water Assessments (SWA). These SWAs were completed for all active PWSSs in 2004, as required by the 1996 amendments to the Safe Drinking Water Act, and funded by USEPA. The assessments identified all potential sources of contamination for each public water supply system and evaluated the susceptibility of the PWS to contamination. The SWAs were the first step in a comprehensive plan for protecting the public drinking water supply system. PWSSs and their surrounding communities use the SWA and the accompanying Susceptibility Analysis Scores to determine the contaminants and activities that pose the greatest threats to their water supply.

The DWP plan evaluates past SWA reports and performs a drinking water source investigation that uses various water monitoring, modeling, and evaluation techniques to update knowledge of the potential for drinking water contamination. The plan describes current conditions of the drinking water protection area, including age of the PWSS, environmental assessments and investigation results, population, and land use. A completed plan describes action steps needed to protect the drinking water source. Implementation of the action steps is clearly outlined and scheduled along with a list of resources (funding, technical assistance, regulations, etc.) needed to fulfil the DWP plan objectives and goals. Milestones and a monitoring schedule allow the PWSS to track its efforts in implementation.

In addition to the DWP program, drinking water sources benefit from BMPs through WRAPS program. There are 73 public water supply systems (serving approximately 1,277,288 Kansans) relying on surface water sources from streams and/or reservoirs that directly benefit from NPS/WRAPS watershed project implementation.

Local Environmental Protection Program

The LEPP is administered by KDHE and has had several funding sources. From SFY1990 through SFY2010, it was funded by the Kansas Water Office (KWO) under the auspices of the State Water Plan. For SFY2011 and SFY2012, grant funds were allocated through the State General Fund. The program provided financial assistance to local governmental units developing and implementing environmental protection plans on behalf of their respective jurisdictions. All such plans included a sanitary code for regulating private water wells and private onsite wastewater treatment systems, and in addition addressed subdivision drinking water and wastewater treatment, solid and hazardous waste disposal, public water supply protection, and NPS pollution abatement. The program has provided no financial assistance to local governments since SFY 2013, so local governments now provide funding for the program through county general funds and user fees.

The role for KDHE has shifted from grant administration to providing technical assistance, information, and education to support local officials in administration of their Environmental/Sanitary Code. Currently 103 of the 105 Kansas counties participate in this program. The LEPP program is in the implementation phase of a five year plan designed to improve the efficiency in which local officials receive information, technical assistance, and guidance. Elements of this five year plan include:

- Develop a Model Environmental Sanitary Code to assist counties with code updates
- Update the procedure for Environmental Sanitary Code adoption or revision
- Develop a web page for septic haulers and pumpers
- Conduct a nutrient loading study for onsite wastewater systems
- Update the Kansas Environmental Health Handbook
- Update the LEPP web page
- Develop an online training center for sanitarians

Other Nonpoint Source Pollution Control Projects

Background and History

One of the Goals in the Kansas Nonpoint Source Management Plan is to institute a revolving loan fund for NPS projects, and to that end KDHE Watershed Management Section and KDHE Municipal Programs Section have formed a partnership.

This effort was begun in 2009, when approximately $5.7 million of the American Recovery & Reinvestment Act (ARRA) funding was set aside to support NPS/green infrastructure projects administered through the Watershed Management Section (WMS). Eleven projects were awarded in the form of low-interest loans with principal forgiveness. Funded projects used innovative technologies for sustainable stormwater management and NPS pollution abatement, such as constructed wetlands, native grass plantings, pervious pavement, bioretention swales, rain gardens, and stormwater reuse systems, as well as some streambank stabilization and restoration work.

Green Project Reserve

In FFY 11 and 12 (October 2010-September 2012), the Kansas Water Pollution Control Revolving Fund (KWPCRF), which has traditionally been used for treatment plant upgrades, reserved $5.1 million of its funding over two years for Green Project loans. The fund issued a Call for Proposals that outlined submission requirements, project eligibility, and applicant qualifications for NPS projects funded through the KWPCRF. Selected projects were notified of the funding award; pre-award meetings were held to outline the loan application process and requirements; and efforts continued to complete loan applications and secure executed loan agreements. A total of 11 projects have been funded since 2011. These projects included streambank stabilization, restoration with riparian/vegetated buffers, pervious pavement with underdrain systems for stormwater storage, and bioretention swales and rain gardens.

Local Conservation Lending Program

The Local Conservation Lending Program (LCLP) was officially created during the 2014-2015 legislative session through the passage of House Substitute for Senate Bill 36 (H Sub for SB 36). The bill authorizes KDHE to implement the program throughout the state of Kansas. The purpose of the program is to make funds available through a linked-deposit system to local banks, in exchange for low-interest loans to eligible borrowers for water quality protection projects. Eligible projects fall into four main categories: General Conservation Projects, Livestock Projects, Stream Restoration Projects, and Onsite Wastewater Assistance.

Through the continued partnership between the KDHE WMS and KDHE Municipal Programs Section, approximately $1 million annually in KWPCRF set-aside funds has been made available for four years for the LCLP deposits/investments. The program can be combined with other cost-share programs for qualifying projects, providing an additional means to leverage state resources to implement high priority projects aimed NPS pollution abatement.

Since the LCLP statutes were enacted July 1, 2015, the KDHE WMS developed an Appendix to the Kansas Nonpoint Source Pollution Management Plan, to establish the criteria, requirements, and procedures for implementation of the program as directed in K.S.A. 2015 Supp. 65-3330. The Appendix includes eligibility criteria, practices eligible for funding through the program, eligibility criteria for borrowers, eligibility criteria for costs, project completion and certification requirements and process, and other program requirements.

KDHE completed a successful 'pilot phase' of the program, in which prospective lending institutions (banks) and test projects were identified. The goal of this phase was to work through several projects in close coordination with participating lenders and agency partners in order to address any comments or concerns as well as refine the program process. The official statewide program was rolled out in July 2016.

Cost/Benefit Assessment

The direct and indirect costs of water pollution control can be measured, or at least estimated, with some degree of confidence. In contrast, environmental benefits stemming from pollution control are less amenable to expression in monetary terms. Section 101(a) of the CWA establishes national water quality objectives and interim goals reflecting the belief that the costs of water pollution control are outweighed by the ecological and social benefits of clean water. The following paragraph and accompanying tables address some of the major costs associated with water pollution control efforts in Kansas.

Pollution control expenditures in the state are associated predominantly with administrative expenses, capital investments, and operational costs for WWTFs. Although little information is available regarding the control costs borne by industrial and agricultural facilities, capital expenditures associated with the construction and upgrading of municipal WWTFs have been documented by KDHE. For example, the department administers the Kansas Water Pollution Control Revolving Fund (KWPCRF), which provides low interest loans to municipalities for water pollution control projects. Available monies are maximized through the sale of "leveraged revenue bonds." During the past twenty-eight years, these bonds have provided 463 loans totaling $1.22 billion for facility improvements. KDHE also coordinates with the Community Development Block Grant (CDBG) program, which is administered by the Kansas Department of Commerce. This program typically provides grant funding for about 50% of the costs of a selected water pollution control project. During 2016 and 2017, KWPCRF, CDBG, and other state and federal programs provided about $124.6 million in financial aid to communities (**Table 4**). NPS pollution abatement measures received much less funding, relying instead on predominantly voluntary measures and cost-share programs previously discussed.

Table 4. KDHE cooperative funding for construction and expansion of municipal wastewater treatment facilities

Funding year	KWPCRF +	CDBG +		RD +	TOTAL
	Basic Program ++	Federal	Match++	Federal	
2016	$ 41.48 M	$ 3.122 M	$ 0	$ 2.771 M	$ 47.373 M
2017	$ 52.54 M	$ 3.234 M	$ 0	$ 21.468 M	$ 77.242 M
Total	$ 94.02 M	$ 6.356 M	$ 0	$24.234 M	$ 124.615 M

Monetary values presented in millions of dollars.
+ KWPCRF = Kansas Water Pollution Control Revolving Fund / CDBG = Community Development Block Grants / RD = Rural Development Grants and Loans
++ All match funding for CDBG projects was provided by KWPCRF or RD

Special Concerns and Recommendations

The current major environmental concerns for the surface waters of Kansas can be divided into four categories: agricultural concerns, municipal/industrial concerns, nuisance aquatic species, and variations in flow regimes.

I. AGRICULTURAL CONCERNS

Given the extent of agricultural land use in Kansas, it is unsurprising that agricultural practices exert a profound influence on surface water quality conditions. Erosion of cropland soils produces elevated concentrations of silt in many streams and lakes, often to the detriment of native aquatic and semiaquatic life. The presence of nitrogen- and phosphorus-containing fertilizers in field runoff promotes nuisance growths of algae and detracts from the recreational and drinking water supply uses of surface water. Stormwater runoff from uncontrolled feedlots, livestock wintering areas, and heavily grazed pastures introduces pathogens and oxygen consuming organic wastes into nearby lakes and streams, sometimes compromising the sanitary condition of these waters. Pesticide residues in streams and drinking water supply lakes can affect aquatic biota and pose potential long-term risks to human health.

Nonpoint source pollution potential has also been increased through conversion of grassland and good riparian areas to commodity crops, mainly corn. When commodity prices increased and United States Department of Agriculture (USDA) started subsidizing crop insurance, thousands of acres of Conservation Reserve Program (CRP) land and non-CRP grass and riparian areas were converted to corn. Even though some areas were put into no-till, the removal of deep rooted native species and a developed soil microbe community reduced infiltration, increased the likelihood of erosion and sediment deposition from ephemeral gullying, and increased the need for fertilizers and pesticides. Cropping activity next to streams was also potentially destabilized.

Another trend is that with larger equipment and no-till practices, grassed waterways are deemed as loss of valuable cropland and a deterrent to time-efficient farming. This has led to an increase in the use of underground outlets in association with terraces equipped with risers. These drainage systems often deliver agricultural runoff directly to a water body without any type of natural degradation (sunlight-air) or vegetation treatment. These practices can create a conduit for dissolved and particulate pollutants being discharged near or directly into a stream if there is not adequate containment or filter.

Some financial aid restrictions have already been implemented by KDHE and other state agencies. Additionally, the KDHE Watershed Management Section (WMS) is taking steps to reduce this practice by removing it from the list of practices eligible for the US Army Corps of Engineers (USACE) Section 404 of the Clean Water Act General Permit Ag 40 for practices designed by NRCS in its 5 year reissuance process. In April 2018, when new GP 40 Section 404 Permits are reauthorized, these underground outlets will not be included in blanket approval. Instead, the applicant will need an individual Section 401 WQC, which will enable KDHE to provide more technical assistance to protect and restore water quality conditions in potentially affected water bodies.

The KDHE WMS also strives to realize the water quality benefits of improving soil health through implementation of no-till, cover crops, crop rotation, livestock management systems (*i.e.* percent of organic matter increase, increased bio-microbial activity, water holding capacity, increase availability of nutrients) through infiltration and reduced runoff. Additionally, reduction of soluble phosphorus runoff from surface application may be reduced by better infiltration and better crop utilization through increased microbial activity. Depending on the rotation and type of cover crop, quick and thick growth can help reduce weed pressure by shading them to allow more sunlight to get to the cash crop so it can out compete the weed for sunlight. There may also be some weed control through allelopathic characters of certain species of cover crops and some cover crops readily attract beneficial insects for pest control.

Improved soil health can also reduce flood frequency and magnitude. Optimum infiltration into healthy soil reduces peak runoff discharge. This in turn results in more metered flow into the adjacent water body. This can help re-establish base flow in streams cut off from the natural hydrological cycle as well as reduce the impact of runoff events. The ability for this to occur could also provide "cleaner water" to assimilate nutrients in runoff. Subsurface flow is more metered and less forceful, which can mitigate "hungry water" conditions that threaten stream bank and bed stability. The KDHE has been working with WRAPS groups to identify farmers who have started to implement soil health practices. The WMS is also working with the Kansas Department of Agriculture Flood Plain Mapping Program to identify areas where better infiltration could yield significant benefits.

The FFY 16/SFY17 reductions in nitrogen, phosphorus and sediment were accomplished through partnerships between Kansas Department of Agriculture's Division of Conservation, Natural Resources Conservation Service, EPA (Section 319 Program), Kansas Water Office, and KDHE. Partnership activities included financial and technical assistance at the WRAPS level. Practices included both management and structural practices resulting in: 310,196 and 158,779 lbs/yr of nitrogen and phosphorus respectively and 110,347 tons/yr of sediment. However, WMS and EPA are encouraging less structural and more management based (soil health improvement practices); these are envisioned to be more cost efficient with multiple benefits as described above.

Efforts to alleviate the impacts of agriculture on the aquatic environment have focused primarily on the abatement of soil erosion and proper management of chemical fertilizers, biocides, and livestock wastes. Although the wider adoption of agricultural BMPs is underway and should lead to measurable reductions in stream contaminant levels, runoff water quality is not the only agricultural factor limiting the use attainment of surface waters. Throughout much of western Kansas, decades of irrigated crop production have exacted a heavy toll on stream life by lowering groundwater tables, reducing base streamflows, and transforming formerly perennial waterbodies into intermittent or ephemeral systems. In some areas of northeastern Kansas, stream channelization has radically simplified the original aquatic habitats and decimated a formerly diverse fish and shellfish fauna. Impoundments (large and small) throughout the state have encouraged the establishment of predominantly nonnative fish assemblages, fragmented the remaining stream habitats, and diminished the seasonal peak flows required by certain native fishes for spawning and egg development.

The complete restoration of degraded aquatic ecosystems would require large-scale habitat rehabilitation efforts and fundamental changes in the laws, policies, and practices currently dictating the use and allocation of water in Kansas. Some more readily implemented options for partially offsetting the historical effects of agriculture include: enhancing minimum streamflows through the State-mediated purchase and retirement of senior water rights, expanding hatchery restocking programs for native fish and shellfish; selectively removing lowhead dams and other barriers to fish migration; installing fish ladders and elevators on larger dams, and other related management initiatives – all in addition to concurrent improvements in agricultural practices. Most of these concepts are not new; for example, the importance of maintaining migrational corridors for fish was emphasized repeatedly by Kansas officials during the late nineteenth century but never seriously considered in the course of water resource development (Angelo, Cringan and Haslouer 2003).

Even so, there is improvement, as our scientific understanding, agency collaboration, and shared policies improve. Many efforts are being coordinated more broadly across various state and federal agencies. A Nutrient Reduction Plan was created by KDHE in 2004. In 2010 it was expanded and formalized as the Kansas Nutrient Reduction Strategy, which includes collaboration with the Kansas Water Office, Kansas Department of Agriculture, and Kansas Department of Wildlife, Parks, and Tourism. In 2013, Governor Sam Brownback asked state agencies to work together with his administration on a fifty-year water vision. As a result, the Kansas Water Vision task force and planning documents (State of Kansas January 2015) have created an even more permanent infrastructure for interagency collaboration on issues surrounding statewide water supply and, to some degree, water quality.

The coalition of agencies work with state mechanisms as well as helping to coordinate and leverage federal programs such as USDA Farm Service Agency's Conservation Reserve Enhancement Program (CREP), which provides incentives to remove environmentally sensitive land from production and implement conservation practices.

II. MUNICIPAL AND INDUSTRIAL CONCERNS

Discharging wastewater treatment facilities (WWTFs) and other point sources influence surface water quality throughout much of Kansas. Inorganic nitrogen and phosphorus released from some facilities promote blooms of filamentous or scum-forming algae in downstream waters and detract from their capacity to support primary and secondary contact recreation. Bypasses of raw or partially treated sewage occur each year, owing to treatment plant capacity limitations, malfunctions, operator error, and natural catastrophes. Such bypasses can result in fishkills and other serious water quality problems.

Stormwater runoff from lawns, golf courses, roadways, parking lots, and construction zones often contains a complex mixture of chemical pollutants (*e.g.*, herbicides and pesticides, fertilizers, oil, grease, antifreeze, de-icing salts, solvents, detergents, asbestos). These substances can prevent the development and maintenance of representative aquatic communities in receiving surface waters. Similarly, concentrations of mercury, polychlorinated biphenyls (PCBs), and other bioaccumulative contaminants in fish taken from urban streams may pose unacceptable risks to human consumers. In addition, data related to the accumulation, transport and fate of microplastics, animal and human pharmaceuticals, hormones, personal care products, and other ubiquitous chemicals such as perfluorinated compounds (PFCs) and polybrominated diphenyl ether fire retardants (PBDEs) are needed in Kansas as well as the rest of the country. Although the concentrations of such chemicals in the water column are most often minute, the processes of bioaccumulation and subsequent biomagnification in the food chain may concentrate these chemicals in fish tissue to levels that subject human and wildlife consumers to a risk of deleterious effects. Consumers of fish exposed to these contaminants and/or their degradation products may be exposed to concentrations in fish tissue many times greater than the concentrations occurring in the ambient environment, and many are resistant to removal by drinking water treatment plants (Glassmeyer 2017). Although the USEPA has long acknowledged the importance of monitoring and determining safe levels of these contaminants of emerging concern (CECs) in both water (Stephen, et al. 1985) and fish tissue (USEPA 2013), analytical costs for many of these compounds remain high, and financial support for implementation at the state level has not been forthcoming.

Unplanned and extensive urban growth can negatively influence the physical habitats supporting aquatic life, in part because eliminating and altering permeable land surfaces, wetlands, and riparian areas diminishes urban watersheds' capacity to remove pollutants and mitigate the effects of flooding. Stormwater runoff from impervious surfaces such as paved areas and rooftops can lead to powerful flooding events, capable of scouring stream bottoms and eliminating the habitat required by some native aquatic species. The channelization of urban streams results in highly simplified aquatic habitats incapable of supporting the full range of fish, amphibians, invertebrates, plants, and wildlife indigenous to this region. In many instances, the negative effects of high density development on streams, lakes, and wetlands could be reduced through urban planning, employing established BMPs, maintaining green corridors around water bodies, and strategically designing the placement of development. The retention of natural corridors or "greenways" along rivers and creeks, and observance of the intent of the antidegradation provisions of the surface water quality standards (KDHE 2015), would do much to preserve the natural physical and chemical attributes of the state's urban streams. Local, state, and federal authorities also could support more litter cleanup initiatives. Improving the visual and aesthetic character of urban waters would increase their perceived value and encourage protection and sustainable use.

Some streams also suffer from illegal dumping of trash and other unwanted materials. The practice of discarding grass clippings, brush, and animal carcasses into streams (and the subsequent decay of these materials) reduces dissolved oxygen levels, jeopardizes populations of fish and other aquatic life, and may introduce pathogens. Discarded appliances and electronics, paint cans, pesticide containers, and batteries may leach toxic materials, thereby posing a threat to resident aquatic biota.

On a positive note, the deliberate and systematic renovation of many wastewater treatment facilities has noticeably improved surface water quality over the past few decades, and this progress continues. As point sources contributing to water quality impairments decline, attention will shift increasingly to nonpoint sources. Watershed pollution control efforts, predicated largely on the development and implementation of TMDLs, through WRAPS, will play an increasingly important role in abatement of nonpoint source pollution.

III. NUISANCE AQUATIC SPECIES

Several exotic plant and animal species have established populations within the state, and some pose a serious risk to native aquatic life and the beneficial uses of surface waters. For example, Asian clams (*Corbicula fluminea*) have established large populations in streams and lakes throughout the state, and the zebra mussel (*Dreissena polymorpha*) has gained a foothold in recent years in several major river basins. Both of these exotic bivalves can compete with or otherwise injure native shellfish species, and the zebra mussel in particular can impair designated recreational and drinking water supply uses. At least three species of Asian carp have been reported in Kansas (bighead carp, *Hypophthalmichthys nobilis*; silver carp, *Hypophthalmichthys molitrix*, and grass carp, *Ctenopharyngodon idella*), as well as white perch *(Morone americana)* and rudd *(Scardinius erythrophthalmus)*; additional exotic fishes are expected to appear in Kansas in the near future. These animals can compete with native fish and wildlife for food and shelter, and some dramatically reduce water clarity by disturbing bottom sediments during feeding. Zebra mussels and other invasive species also create significant costs to manage and mitigate (Connelly, et al. 2007).

A number of introduced plant species also have proven problematic. Thickets of salt cedar (*Tamarix* spp.) have become established along many streams in western and central Kansas, crowding out the native riparian vegetation and removing (via evapotranspiration) vast amounts of water from the adjoining streams and underlying alluvial aquifers. Purple loosestrife (*Lythrum salicaria*) has become the dominant herbaceous species in many wetlands, overwhelming many of the state's native plants and jeopardizing the animals depending on these plants for food and shelter. Eurasian watermilfoil (*Myriophyllum spicatum*), an exotic plant sold in the aquarium trade, has been documented in several streams in western Kansas and in scattered lakes throughout the state. This plant propagates via seeds and vegetative fragments and can spread rapidly between waterbodies by attaching to boat propellers, boat trailers, and fishing gear. Curly-leaf pondweed (*Potamogeton crispus*) has also been found in seven publicly accessible lakes. Once introduced into a lake or stream, these plants can form dense mats of vegetation that can interfere with recreational activities, crowd out native aquatic vegetation, disrupt the feeding behavior of native fish, and choke water intakes used for municipal water supply, power generation, and irrigation. An even more invasive and potentially damaging exotic aquatic plant. Hydrilla (*Hydrilla verticillata*) has been discovered in two discrete locations in northeast Kansas during the last few years (an urban park lake, and a restaurant's outdoor water garden). The expansion of this exotic aquatic species carries with it, based on experiences elsewhere, and even greater potential for environmental and water infrastructure damage.

IV. VARIATION IN FLOW REGIMES

Aquatic plants, animals, plankton, and microbes are adapted to live in particular environments. For example, some fish do best in fast-flowing riffles, whereas others thrive in deep lakes. Even within a given species, habitat requirements may change over the course of a lifetime or on a seasonal basis, to support survival, growth, and reproduction. Alteration of flow regimes from historical, natural conditions can disrupt habitat and affect individual species, relationships in food webs, and the aquatic community as a whole.

Throughout history, humankind has recognized the need to manage natural resources in a way that makes them usable but also sustainable, and this requires balancing priorities. For example, we construct dams to create reservoirs, which help control flooding and create stable water supply sources. At the same time, we recognize that impounded systems must also release water to support downstream uses, at a rate and on a schedule that supports the habitat requirements of aquatic communities as well as the water rights of human users downstream. Over time, we adjust our management policies and priorities as we gain knowledge and understanding.

Many factors, both natural and anthropogenic, can change the amount and timing of streamflow. Direct withdrawals from a stream (for example, for domestic, municipal, or industrial use) and discharges to a stream (from point sources) are easily observable impacts, but other impacts are less obvious. Changes in groundwater levels can affect baseflow conditions. A recent study on southwest Kansas streams has demonstrated a linkage between groundwater withdrawals and declining streamflows (Juracek 2015), which confirms earlier observations of the same patterns (R. T. Angelo 1994).

Flow rates can be accelerated, slowed, or stopped by changing or confining the contours of stream channels – through straightening, dredging, installing levies and revetments, and the like – or by introducing impoundments, which range from major reservoir projects and farm ponds to low-water crossings and beaver dams. Flow can also be changed by modifying the land surface, which affects how precipitation flows overland. Examples of this include installing impervious surfaces, terracing, or constructing ditches and drains. Any of these changes, by altering flow regime, can in turn propagate a cascade of changes both upstream and downstream as the stream or river redistributes sediments, changes its depth, width, and course, and returns to equilibrium.

Overlaid upon these other alterations (both anthropogenic and natural), changes in weather patterns can produce dramatic and readily observable changes in streamflow. The amount, timing, and rate of precipitation all affect streamflow, and these factors interact to determine the absolute and relative rates of runoff, evaporation, infiltration, and groundwater recharge. In the past fifteen years, Kansas has witnessed two major droughts (2000-2006 and 2010-2013) as well as numerous instances of localized flooding. If weather trends observed in Kansas over the past 30 years continue, with gradual increases in both absolute precipitation and temperature over time (National Oceanic and Atmospheric Administration 2016, National Oceanic and Atmospheric Administration 2016), this will undoubtedly shift the seasonal baselines of surface water availability.

Changes in historic, natural streamflow patterns affect not only habitats available for aquatic communities, but also transport of sediment and pollutants. The majority of pollutant loads to streams and lakes is borne by relatively large, short-duration, infrequent storm events and their associated runoff production. The magnitude of these runoff events may overwhelm most Best Management Practices, when they exceed the typical design storm (*e.g*., 25-yr recurrence interval) handled by those practices. Alterations to historic rainfall-runoff responses, such as changes in climate patterns that intensify storms, or increases in a watershed's impervious cover that reduce infiltration, increase the likelihood of damaging runoff and pollutant loads being delivered to water bodies despite investments in BMPs. Conversely, conditions that prolong or aggravate low flow situations induce flow stagnation, which extends the time that pollutants are in contact with aquatic life and prevents beneficial re-aeration that cleanses the stream systems.

Many of the factors that affect streamflow variation are difficult or impossible to manage. The Clean Water Act does not directly address flow management, so pollution resulting from flow alterations defy the typical regulatory tools provided by the Act. Even so, it in our shared best interest to understand, anticipate, mitigate, and plan our responses, given that alterations of natural flow regimes will likely present increasing challenges to managing water quality and maintaining water supplies.

V. CONCLUSIONS

Taken together, these threats can seem daunting. However, various state and federal programs are making incremental efforts to abate the impacts of those activities. For example, NPDES permits tying urban stormwater to impaired waters and directing appropriate corrective practices have been drafted. Kansas is implementing a State Nutrient Reduction Strategy to reduce phosphorus and nitrogen in surface waters. WRAPS groups direct funding to critical subwatersheds to reduce NPS pollutant loads, and the Subwatershed Monitoring Program tracks improvements.

Many of these activities have been tied together and enhanced through the Kansas Water Vision (State of Kansas January 2015). Several of the Phase I Action Items already underway deal directly with nutrient and sediment issues. Although the primary focus in many efforts is reducing sediment and nutrient transport into drinking water reservoirs, many applicable management practices limit movement of other pollutants as well. Along with interagency collaboration, a centerpiece of Water Vision initiatives is citizen engagement. This builds on the tradition of education campaigns implemented by KDHE, KDWPT, and others to create awareness of water quality issues, promote precautions that limit migration of invasive species, and encourage water conservation.

One important innovation of the Kansas Water Vision task force has been to create fourteen Regional Planning Areas (RPAs). These were created by the Kansas Water Authority in December 2014 and tailored to the resources and needs of different parts of the state. The RPAs are based on a hybridization of Groundwater Management Districts in the west (which are based on boundaries of the High Plains Aquifer and counties) and river basins in the east. Each RPA has a Regional Advisory Committee; these entities replace Basin Advisory Committees. This configuration of local representation reflects Kansas' long-standing acknowledgement that surface water, alluvial groundwater, and deep groundwater are distributed unevenly across the state and that these local variations of interconnected water resources must be understood and factored into policy deliberations.

Another important component of the state Water Vision is the convention of the Blue Ribbon Task Force, which was given the assignment of identifying funding needs as well as possible funding sources to insure sustainable water supply for the state. The Blue Ribbon Task Force final report, with recommendations, was produced in 2017 (State of Kansas 2017).

There have also been structural changes to state water use law that will encourage conservation; these include elimination of the "use it or lose it" rule for groundwater rights and introduction of multiyear flex accounts that allow irrigators to budget water use over five years rather than one (Kansas House Bill 2451 and Kansas Senate Bill 272; see Kansas Water Authority 2012). In 2012 the Legislature authorized Local Enhanced Management Areas (LEMAs) in western Kansas to combat groundwater declines through local management strategies (Kansas Senate Bill 310 / K.S.A. 82a-1036), and one is already in place. In April 2017, the Governor signed into law Senate Bill 412, which approves construction of a hydropower energy facility to benefit Kansas River Assurance District, which includes one of the largest drinking water producers in the state.

Broad-based conservation and restoration collaborations proceed as partnerships, mechanisms, and funding become available. For example, KDWPT, in partnership with the US Fish and Wildlife Service and the City of Wichita, is installing a fish passage structure in the Arkansas River, which is Designated Critical Habitat for several state-listed fish species.

In a February 2015 settlement with Nebraska over the Republican River Compact, Kansas recently received \$5.5 million; of this, \$3.5 million will be used for conservation projects in the Lower Republican River Basin, with oversight from the Kansas Water Office; much of the funding will be used for irrigation efficiency infrastructure in the northcentral part of the state. In the southeastern corner of Kansas, which has a long mining history, KDHE is working with Pittsburg State University's Monahan Research Center and the federal Office of Surface Mining to design a remediation wetland to treat acid mine drainage.

Another restoration project underway in southeast Kansas is aimed at restoring native aquatic communities. In March 2014, KDHE and KDWPT signed a Memorandum of Agreement to implement Natural Resource Damage Assessment (NRDA) activities at the Farlington State Fish Hatchery. This Memorandum included a provision for some funding by KDHE to KDWPT for the implementation, construction, operation, management, and maintenance of a native species facility, called the Kansas Aquatic Biodiversity Center (KABC). Construction is nearly complete, and the KABC is scheduled to open in 2018. This facility will serve as a hatchery for native freshwater mollusks as well as fish. These native species will be used in a variety of restocking and restoration efforts. Many species are imperiled or in need of population augmentation, while other species need re-establishment due to natural resource damage.

Over time, these programs can improve the health and intrinsic value of our aquatic ecosystems, thereby increasing their economic and cultural value to the citizens of Kansas. Effective program implementation requires investment in continued systematic, thorough, high quality monitoring of water resources and aquatic communities. This will direct limited resources to the highest priority waters while building a foundation of sound scientific evidence to evaluate and improve restoration strategies and measure their success.

PART C. SURFACE WATER MONITORING AND ASSESSMENT

Monitoring Programs

In Kansas, the Kansas Department of Health and Environment (KDHE) is the agency that bears primary responsibility for surface water quality monitoring and assessment of the state's surface water resources. This work is accomplished through six long term monitoring programs housed in the Watershed Planning, Monitoring, and Assessment Section of the Bureau of Water. The six Monitoring Programs are: Lake and Wetland, Targeted Stream Chemistry, Targeted Stream Biology, Probabilistic Stream, Fish Tissue Contaminant, and Compliance. The Subwatershed Water Quality Monitoring Program and several other cross-program initiatives and special projects are operated by the same program staff. The Surface Water Use Designation Program does not currently have a dedicated staff, but still maintains a methodology that is implemented by section personnel.

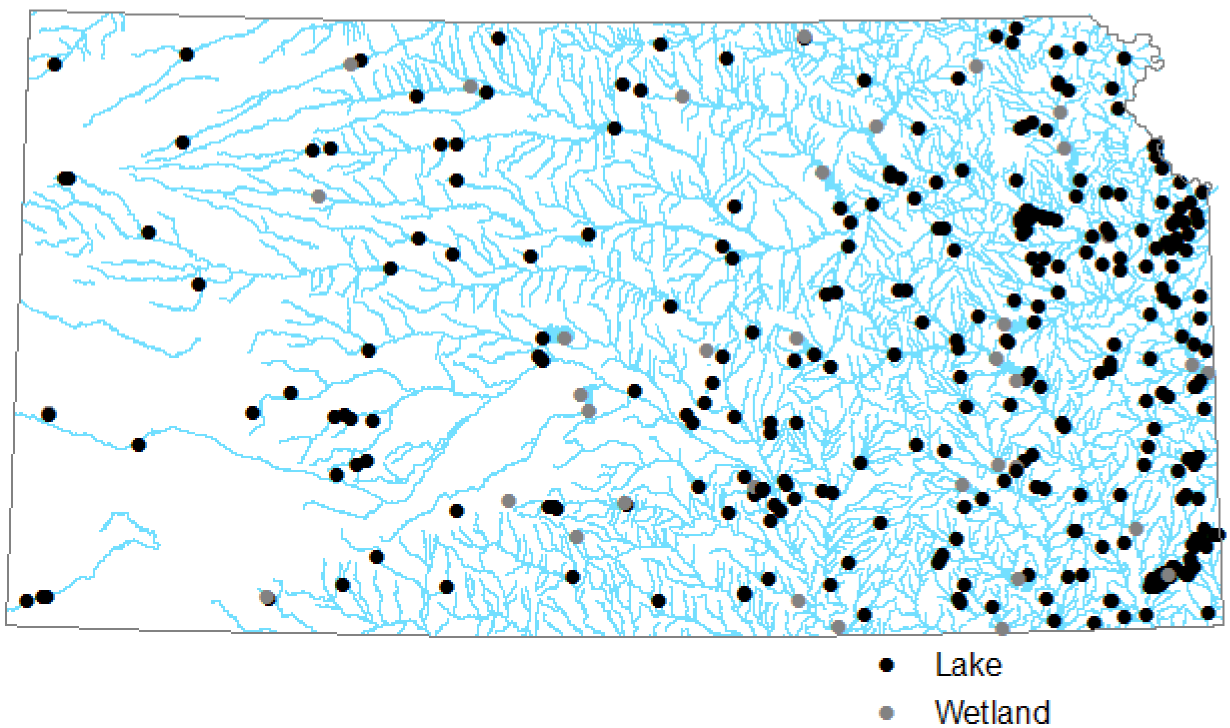
Water quality grab samples collected by these programs are analyzed at the Kansas Health Environmental Laboratories (KHEL) for a suite of physical, organic, inorganic, and bacteriological parameters. As of 2016, KHEL contracts with the State Hygienic Laboratory at the University of Iowa (Coralville, Iowa) to analyze the agency's ambient radiological water quality samples. Fish tissue mercury samples are analyzed at EPA Region 7 laboratories. Other types of samples are processed and analyzed in house or sometimes outsourced to contractors, all under the aegis of KDHE and its approved Quality Assurance Management Plans.

For detailed information on methods as well as the developmental history and current status of KDHE's environmental monitoring programs, the reader is referred to the applicable quality assurance management plans (QMPs) and standard operating procedures (SOPs) posted on the departmental website (http://www.kdheks.gov/environment/qmp/qmp.htm#BOW).

I. TARGETED LAKE AND WETLAND MONITORING PROGRAM

This program surveys water quality conditions in publicly owned and/or publicly accessible lakes and wetlands throughout Kansas (KDHE 2017). Program personnel visit individual waterbodies on a three-to-six year rotational schedule, and field measurements and subsequent laboratory analyses provide data on a large suite of physical, chemical (inorganic and organic), and biological (phytoplankton and macrophytic communities) parameters (Appendix A). Macrophyte community composition and areal coverage are evaluated in selected waterbodies smaller than 200 acres. The program's primary database now contains over 400,000 analytical records representing more than 350 waterbodies. Watersheds associated with many of these lakes and wetlands are surveyed periodically with respect to prevailing land use/land cover and the location and size of discrete pollutant sources (WWTFs, CAFOs, *etc.*).

Figure 2. Targeted Lake and Wetland Monitoring Sites



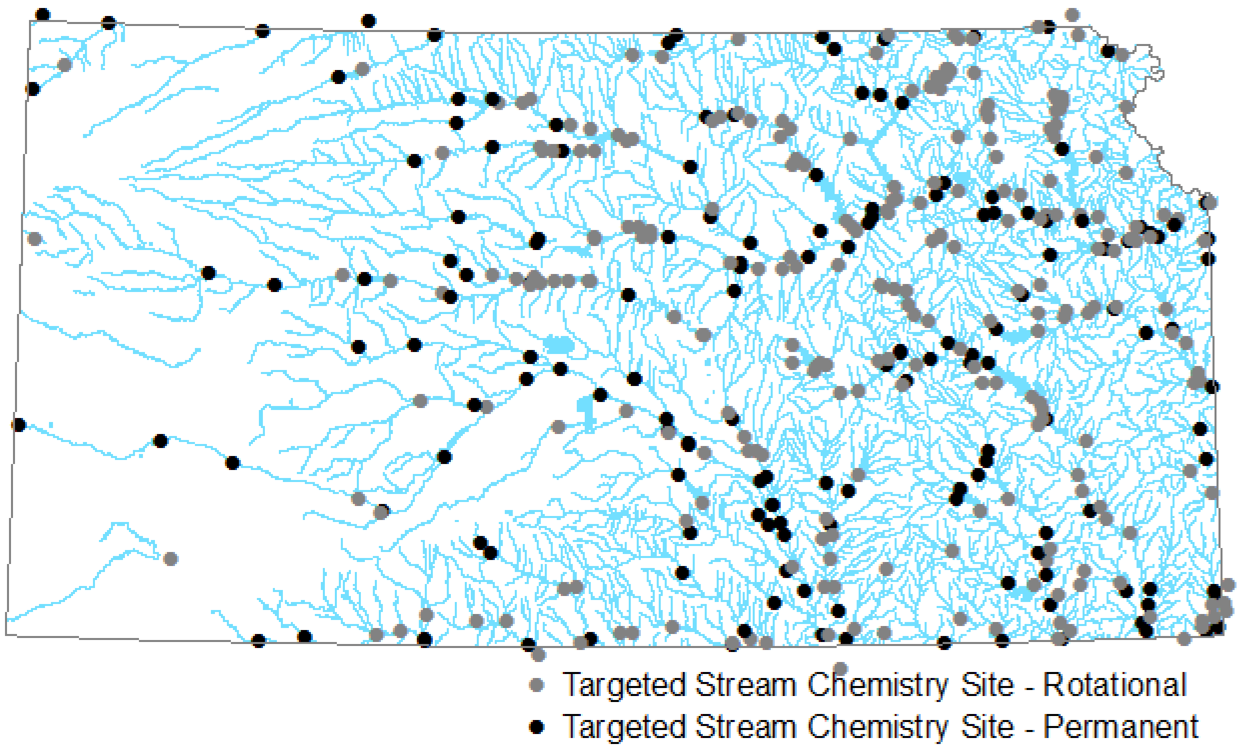
As of December 2017, baseline water quality information is obtained from a dynamic ambient sampling network of 177 selected lakes and wetlands distributed throughout the state. These include all 24 federal lakes, most state-administered fishing lakes (those with open water in the majority of years), various other state, county, or locally owned lakes, several privately owned but publicly accessible lakes (primarily for water supply), and six state or federally owned wetlands. In addition to the lakes and wetlands routinely monitored in this program, other standing waterbodies have been subjected to less intensive investigation throughout the program's tenure. A number of waterbodies were evaluated from a single survey for basic water chemistry, nutrient and trophic status, and water clarity. In other cases, physicochemical and biological data were collected from surveys occurring prior to the most recent six-year rotating sampling period. Inclusion of these sites in the current assessment is limited to results tied to the trophic status of the waterbody at the time of evaluation.

Because only a small number of Kansas lakes are natural in origin, an effort has been made to identify artificial lakes in minimally disturbed/developed watersheds to serve the function of reference systems. This program routinely shares a large amount of data and expertise with other agencies and organizations involved with lake and wetland management, environmental restoration, water quality monitoring, and environmental education. Additional collaborative efforts have addressed the abatement of toxic algae blooms and taste/odor problems in public water supplies.

II. TARGETED STREAM CHEMISTRY MONITORING PROGRAM

The department's stream chemistry monitoring program, specifically the stream chemistry sampling network, comprises over three hundred monitoring sites that survey water quality conditions in all the major river basins and physiographic regions throughout Kansas (**Figure 3**). This program's monitoring operations provide critical information for environmental protection, overall quality assessment, and evaluation relative to deviation from historical hydrological conditions. They play an important role in the development and refinement of TMDLs for 303(d)-listed streams. Appendix A provides a list of the routine and supplemental water quality parameters analyzed by the targeted stream chemistry program.

Figure 3. Targeted Stream Chemistry Monitoring Program Sites

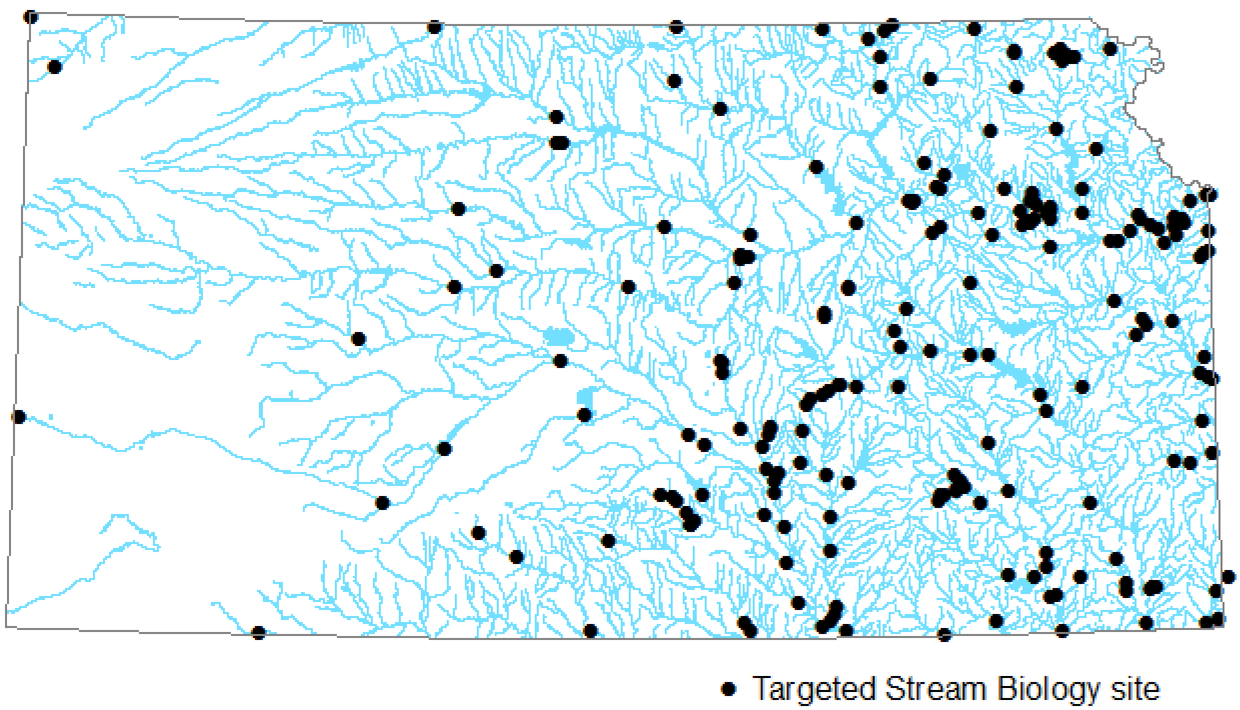


On a quarterly basis, data on stream chemistry are obtained from over 200 monitoring stations. In a given year, staff of the BOW Watershed Planning, Monitoring and Assessment Section visit 162 permanent sites (monitored every year) and approximately 42 rotational sites (monitored every fourth year). These sites represent water quality conditions in targeted watersheds or specific stream reaches that are typically located near the lower terminus of eight-digit hydrologic unit code (HUC) watersheds For example, some sites reflect water quality conditions in streams as they enter or exit Kansas, others represent conditions above or below major WWTFs, urban areas or reservoirs, and still others reflect water quality conditions in predominantly rural watersheds. A few "minimally altered" and several "least impacted" reference streams are included in the network to gain a better understanding of baseline water quality conditions in various ecoregions **(Chapman, et al. 2001)**. As currently configured, the network provides water quality information useful to characterizing pollutant loadings from more than 97 percent of the state's contributing drainage area.

The program database comprises over two million records representing nearly 400 active and inactive monitoring locations and approximately 100 different analytical parameters. The stream chemistry monitoring program is the longest running environmental monitoring operation administered by KDHE; some records in the database date to the late 1960s, and several monitoring sites have a continuous period of record extending from that time to the present **(KDHE 2014)**.

III. TARGETED STREAM BIOLOGICAL MONITORING PROGRAM

Figure 4. Targeted Stream Biological Monitoring Program Sites



This program examines the structural attributes of aquatic macroinvertebrate assemblages to provide a more refined picture of the ecological status of streams (KDHE 2012). Unlike water chemistry measurements alone, which reflect conditions occurring at the moment of sample collection, biological monitoring provides an integrated measure of environmental condition over time frames ranging from weeks to years, depending on the biological assemblage of interest. The majority of the program's monitoring sites are also Stream Chemistry Monitoring Program sites. Fewer biological monitoring stations can be visited throughout the year than chemistry stations; however, combining biological and chemical sampling at selected key sites provide a more complete picture of ecological status than either method alone. Samples normally are obtained from 45-65 network sites each year as dictated by TMDL development needs, special projects, or other regulatory considerations.

Over the course of 40 years, the program has developed a sampling network that includes 222 current and historical monitoring sites distributed throughout the state (**Figure 3**). Some stations have been sampled annually for the entire period of record. The program's database currently contains over 80,000 predominantly genus/species level records (over 501,000 individual organisms), and a separate freshwater mussel database contains approximately 15,000 high resolution records. Data from this program are used primarily in the development and refinement of TMDLs for 303(d)-listed streams and special studies.

IV. PROBABILISTIC STREAM MONITORING PROGRAM

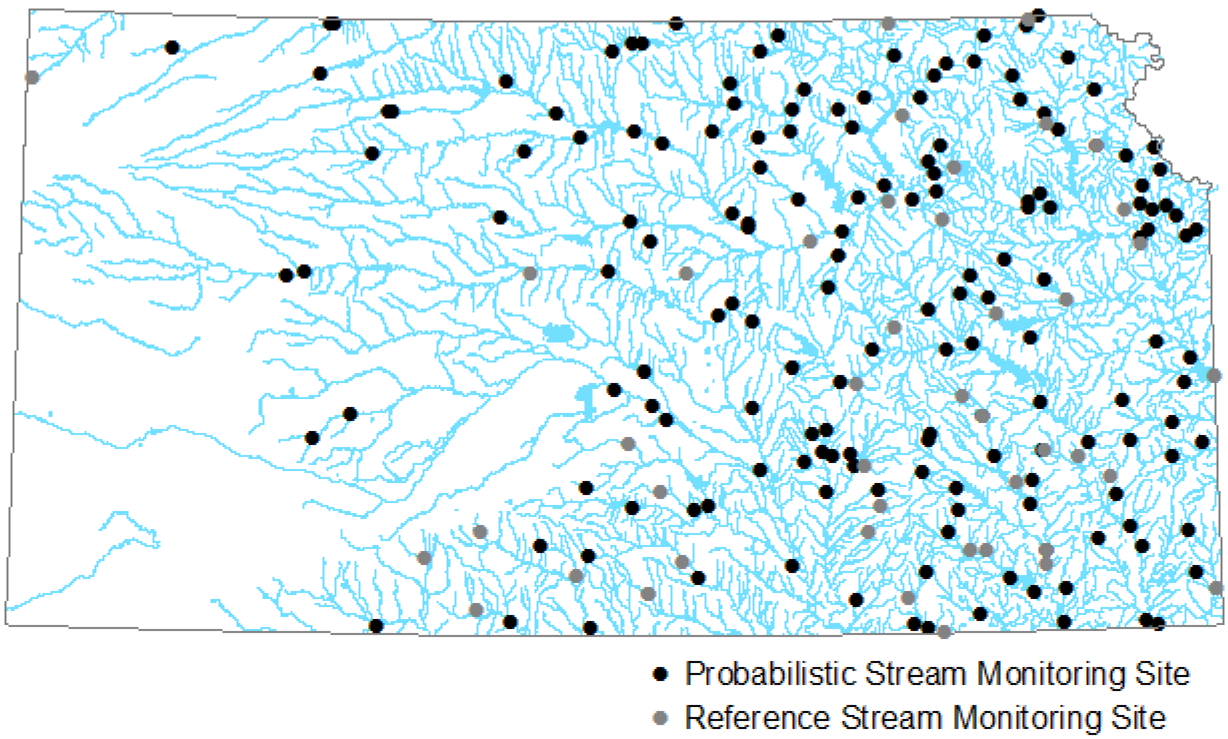
Probabilistic sampling is a method of environmental monitoring that yields statistically valid representative information on the physical, chemical, and/or biological condition of natural resources. It differs from conventional targeted sampling in that probabilistic monitoring stations are a randomly selected subset of the resource as a whole. In Kansas, stream chemistry and stream biological monitoring programs traditionally have employed a targeted monitoring design that positions stations in a deliberate and strategic manner (*e.g.*, near the terminus of a specific watershed or above and below a discrete pollution source). Although these programs are of critical importance in determining site- and watershed-specific water quality conditions, funding and logistical constraints limit the number of targeted sites that can be sampled on an ongoing basis. In contrast, probabilistic monitoring focuses on the total resource rather than the individual monitoring locations. Results generated from this approach can be extrapolated with known confidence to the state's entire population of streams, including hundreds of smaller waterbodies (*e.g.*, headwater streams) largely outside the purview of the targeted monitoring programs.

In 2004, KDHE participated in USEPA's National Wadeable Streams Assessment and gained a familiarity with the application of probabilistic sampling designs and associated field methods (USEPA, 2006 and http://water.epa.gov/type/rsl/monitoring/streamsurvey/index.cfm). In 2005, availability of supplemental monitoring funds under section 106(b) of the CWA allowed KDHE to establish a probabilistic monitoring program. This effort was formally implemented in June 2006 under the auspices of the newly created Kansas Stream Probabilistic Monitoring Program (SPMP).

Probabilistic stream monitoring addresses 305(b) data needs, whereas targeted monitoring serves as the primary basis for 303(d) list development, TMDL formulation, and NPDES permit review and certification. Although site selection procedures for the probabilistic and targeted monitoring programs differ substantially, many field methodologies developed for the targeted programs have been integrated with little alteration into the probabilistic program. This decision has maintained methodological continuity across programs and facilitates inter-program data comparisons.

The SPMP sampling network is predicated on a random, but spatially balanced, site selection process (Kaufmann, et al. 1991, Messer, Linthurst and Overton 1991, Larsen, et al. 1994, Urquhart, Paulsen and Larsen 1998, Herlihy, Larsen, et al. 2000, Herlihy, Stoddard and Burch-Johnson, The relationship between stream chemistry and watershed lend cover data in the mid-Atlantic region, U.S. 1998). Site coordinates are based on the random selection of points from the universe of classified stream segments identified in the most recently approved version of the Kansas Surface Water Register (KSWR) (KDHE, 2010a). This register represents all potential sampling locations or "the sampling frame." It is subject to incremental change over time owing to the deletion or addition of classified stream segments (KAR, 2004; KDHE, 2012c). In effect, an infinite number of potential sampling sites can be selected from the KSWR, allowing a manageable subset of about 30–50 newly selected sites to be sampled each year. Additional details are given in the SPMP quality assurance management plan (KDHE 2017).

Figure 5. Probabilistic Stream Monitoring Sites, 2011-2015



In addition to the 30-50 probabilistically selected monitoring sites sampled each year, the SPMP maintains a network of 25-35 reference-quality stations, which are chosen to reflect least disturbed waterbody types across the full range of stream sizes, ecoregions (Chapman *et al*, 2001) and major river basins (**Figure 4**). These sites are sampled on an approximately biennial basis using the same methodologies as those used on probabilistic sites. Data from these sites are used to derive thresholds for macroinvertebrate assemblage metrics, which are then used to assess the general population.

Water chemistry samples are collected on a quarterly basis at each monitoring site; see **Appendix A** for parameters. During summer low flow of the same year, SPMP staff visit each site to sample the macroinvertebrate and phytoplankton communities. Physical habitat data also are collected to help discriminate between chemistry- and habitat-mediated constrains on the biotic community. The SPMP staff also obtains permissions to access a subset 12-20 of each year's sites that are on segments designated for food procurement. In cooperation with the Fish Tissue Contaminant Monitoring Program staff, harvestable-sized edible fish are collected at these sites, and their tissue plugs are screened for mercury metals. (Note: the USEPA Regional Laboratory has discontinued analysis of other heavy metals and organic contaminants, so these are no longer assessed.)

As mentioned previously, SPMP personnel employ many field protocols developed originally for the targeted monitoring programs and continue to work closely with staff from those programs, sharing in training, sample collection, and quality control and quality assurance methods. These established protocols are robust, and their utility has been demonstrated over the course of several decades. Moreover, data comparability and consistency among monitoring programs may prove important to future statewide water quality assessments. The SPMP database currently contains over 21,150 high resolution (predominantly genus/species level) macroinvertebrate records for 2006-2015 and over 2,400 water chemistry records for 2006-2016. Separate databases house additional information on physical habitat, freshwater mussels, phytoplankton, and fish tissue.

V. FISH TISSUE CONTAMINANT MONITORING PROGRAM (TARGETED AND PROBABILISTIC)

This program obtains information on chemical contaminant levels in fish collected from streams and lakes in Kansas (KDHE, 2013a). KDHE field staff collect the majority of samples used for reporting and advisories. Additional field support is sometimes provided by the Kansas Department of Wildlife and Parks and Tourism (KDWPT) and USEPA Region 7 staff. All methyl mercury samples are analyzed by the USEPA Region 7 laboratory. Organic contaminant samples (**Appendix A**) were analyzed by the USEPA region 7 laboratory through the year 2014. Organic contaminant samples collected during year 2014 were analyzed by a private contract laboratory for chlordane, DDT, and PCBs only due to budget constraints. The fish tissue database currently comprises over 25,000 records from more than 360 lake, stream, and river sites.

Fish tissue samples are usually obtained from 30-50 waterbodies each year, utilizing both targeted and probabilistic sampling designs. Targeted sampling efforts focus on tracking long term contaminant trends among legacy contaminants such as PCBs and chlordane, waterbodies with known or suspected contamination, existing advisory sites, and waterbodies where fish are heavily harvested by the fishing public. Probabilistic samples from streams, collected in collaboration with the Stream Probabilistic Monitoring Program, provide unbiased data in fulfillment of 305(b) reporting requirements and serve a screening function for ascertaining contaminant patterns that may potentially affect human and wildlife consumers.

KDHE utilizes data consisting of whole body composite organic contaminant samples, fillet composite organic contaminant fillet samples, and mercury fillet plug (biopsy) samples to evaluate potential human health concerns related to mercury, organochlorine pesticides, and PCBs, in part to track long term trends as well as areas with known problems (Arruda, Cringan, et al., Correspondence between urban areas and the concentrations of chlordane in fish from the Kansas River 1987, Arruda, Cringan, et al., Results of follow-up chlordane fish tissue analysis from the Kansas River 1987, KDHE 1988, KDHE 1988). Risk is calculated using standard USEPA methods (USEPA 2000, USEPA 2000). The data are utilized for issuing, rescinding, modifying, or supporting local and state-wide fish consumption advisories. The consumption advisories are published at the beginning of each year jointly with KDWPT (KDHE 2018, KDWPT 2018).

VI. Compliance Monitoring Program

As a National Pollutant Discharge Elimination System (NPDES) delegated state, Kansas has been issuing NPDES permits and conducting compliance sampling inspections since the mid-1970s. As of December 31, 2017, there were 923 NPDES permitted facilities in the state subject to monitoring by this program; see **Table 2.** NPDES permits contain specific and legally enforceable effluent limitations and self-monitoring requirements for flow measurement and sampling. The sampling frequency, the sample type (grab or composite), the parameter limitations, the analytical methods, and the reporting frequency are determined by the permitting agency (KDHE).

Self-monitoring data are submitted to KDHE by the permit holder at intervals and analyzed for parameters specified in the individual facility's NPDES permit. Additional parameters such as metals, nutrients, and organic compounds are frequently sampled to obtain additional information regarding effluent characteristics. Whole effluent toxicity samples have also been collected during compliance sampling. Compliance monitoring includes all field activities conducted to determine the status of compliance with permit requirements. A compliance sampling inspection will accomplish one or more of the following objectives:

- verify compliance with effluent limitations
- verify self-monitoring data
- verify that parameters specified in the permit are consistent with wastewater characteristics
- support permit re-issuance and revision
- support enforcement action

The scope of the Compliance Monitoring program is statewide. Any discharging NPDES permit holder may be subject to compliance monitoring. Facilities are selected by KDHE Bureau of Water regulatory personnel. Program staff currently monitor 20 to 30 facilities per year. During 2016-2017, 43 facilities were visited. From the discharging municipal and industrial mechanical and lagoon treatment systems, 276 analytes were sampled against NPDES permit limits. Seven samples were found to be in exceedance of permit limits at the time of sampling. Compliance monitoring data are stored in a stand-alone database on a secure agency data server and shared with the BOW Technical Services Section.

These observed exceedances in addition to self-monitoring data are also used to investigate actual instream violations of Kansas Surface Water Quality Standards, the vigilance of the Compliance Monitoring Program safeguards the surface waters of the state by ensuring accountability of permitted dischargers.

VII. Subwatershed Monitoring Program

The Kansas Subwatershed Water Quality Monitoring Program (SWMP) was established in 2010 as a cooperative effort between KDHE's Watershed Management Section and stream monitoring programs of the Watershed Planning, Monitoring and Assessment Section (KDHE 2014). It is a cross-program initiative staffed by personnel from pre-existing long term monitoring programs.

The SWMP employs a water quality monitoring strategy that assesses nonpoint pollution on a subwatershed scale and was designed to track water quality improvement in selected HUC-12 subwatersheds over time.

Monitoring efforts target specific Kansas watersheds that have active Watershed Restoration and Protection Strategy (WRAPS) project areas. All the WRAPS projects have detailed plans to address water quality impairments associated with nonpoint source pollutants identified in Total Maximum Daily Load (TMDL) evaluations. The WRAPS plans strategically target particular geographic areas for implementation of agricultural BMPs, which are designed specifically to address nonpoint source pollutants related to TMDLs.

From 2010 to 2015, the SWMP completed five years of monitoring to establish a water quality baseline for the first set of fifteen subwatersheds. The next set of nine subwatersheds has been selected, and monitoring on those sites began in 2016 and is scheduled through 2020. The baseline water quality data obtained from these subwatersheds will be compared to future monitoring data, in order to document load reductions attributable to the implementation of Best Management Practices.

VIII. SPECIAL PROJECTS

Coupled with ongoing efforts to protect the physical, chemical, and biological integrity of the waters of the state, KDHE performs special water quality investigations in support of TMDL studies to strengthen mitigative and enforcement decisions implemented by the department. KDHE began five projects directly related to wastewater treatment facilities:

1. KDHE’s stream chemistry and biological monitoring programs collected ambient surface water quality samples and are examining the changes in aquatic biological integrity in Mill Creek coincident with City of Olathe’s Harold Street wastewater plant rehabilitation project.

2. KDHE determined that sampling sestonic chlorophyll-a in the stream water column provides adequate information at less logistical cost than attempting to evaluate estimated periphyton concentrations from filamentous algae growing on the stream bottom using artificial substrates. Targeted streams included those associated with wastewater treatment plant upgrades aimed at reducing nutrient loading.

3. As construction is planned for new wastewater treatment plants, KDHE collects chemical and biological data above and below the planned outfall. This establishes a baseline to evaluate the impacts of the new plant discharges into the receiving stream once operations commence.

4. KDHE adds new biological monitoring sites on streams to evaluate improvements in wastewater nutrient removal and non-point source abatement efforts triggered by newly developed TMDLs. The biological data are used to support evaluation of TMDL endpoints and inform the next iteration of TMDL implementation efforts by the point and non-point sources discharging nutrients to the streams.

5. KDHE's Compliance Monitoring program samples a select number of discharging wastewater lagoon systems not only at their outfall, but again some distance downstream from their applicable mixing zones, to assess the water quality impact from these small town wastewater treatment systems. The data demonstrate how pollutant concentrations diminished concentrations of pollutants emanating from these relatively low-tech lagoons, better defining the relative impact of small town waste loads.

Assessment Methodology

I. 305(B) ASSESSMENT METHODOLOGY FOR STREAMS

Overview

The target population for the 2018 probabilistic stream assessment comprised that portion of the Kansas Surface Water Register (KSWR) stream extent that contained water during the summer low-flow periods of 2011-2015. The sampling frame used to select sites was drawn from a survey design based on the December 12, 2013, version of the KSWR (KDHE 2013), which represents an extent of approximately 30,278 stream miles, based on a 1:24K resolution. This includes perennial rivers and streams as well as intermittent streams that provide important refugia for aquatic life.

The survey design was generated by the USEPA design team in Corvallis, Oregon (Olsen, Kansas statewide stream survey design. March 11, 2009. 2009), using the methods and assumptions of Stevens and Olsen (Stevens and Olsen, Spatially balanced sampling of natural resources 2004). All desk and field reconnaissance was performed by SPMP personnel, along with securing landowner permissions. The target population was determined to comprise 19,284 stream miles, or about 64% of the KSWR. The target population for assessment of the Food Procurement use was 16,224 miles, or about 73% of the mileage so designated. Data collected during 2011-2015 were used to assess the prevailing level of support for CWA section 101(a) uses (**Table 5**). A few probabilistic sites from the 2013-2014 National Rivers and Streams Assessment were also included; these are based on the same target population and compatible with the state survey design.

The likely capacity of a given stream reach to provide for recreation, food procurement, and aquatic life support was determined by considering the local water chemistry, fish tissue chemistry, suspended bacterial concentrations, and condition of the benthic macroinvertebrate community. Monitoring sites meeting the applicable water quality criteria or diagnostic thresholds for a given use were deemed “fully supportive” of that use. Any site failing to meet these criteria or thresholds was deemed “non-supportive” of the use. Note that the quantity of data and assessment methodologies used here are sufficient for a screening-level assessment for 305(b) purposes, but are not sufficient to support a 303(d) impairment listing or to issue state advisories or warnings.

Table 5. Types of data applied to assessment of designated use support for streams and rivers, 2011-2015

Designated Use	Macroinvertebrate Community Structure	Water Chemistry	*E. coli* Concentrations in Water Samples	Mercury in Fish Tissue
Aquatic Life	X	X		
Recreation			X	
Food Procurement				X
Overall	*X*	*X*	*X*	*X*

Causes and sources of nonsupport are rarely known definitively, but in most cases were inferred and assigned conservatively using best professional judgment and a variety of data sources. Data sources and considerations included: prevalence and proximity of upstream point sources, nonpoint sources, spills, construction, and any other relevant anthropogenic activities or influences, point source performance during the reporting period (if known), dominant land uses within the watershed and near the sampling location, chemical profiles of water samples, and any instream manifestations reflecting degraded water quality (substrate characteristics, bank instability, algal overgrowth, presence or recent evidence of livestock in the stream channel, effluent odors, *etc.*), along with considerations of any known recent extreme weather events, such as drought or flood.

Causes have been assigned at the most proximal identifiable level (*i.e.*, the most directly observable condition), and sources are the anthropogenic and environmental stressors to which the conditions may be most logically attributed. Sources, too, were assigned at the lowest causal level possible, to minimize the degree of uncertainty in conclusions.

Aquatic Life Use

The aquatic life use assessment considered stream macroinvertebrate data and water chemistry data from 163 randomly chosen sites (**Figure 5**). A site was deemed fully supportive for aquatic life only if both the macroinvertebrate community structure and the water chemistry indicated support.

In assessment of the macroinvertebrate community, primary use support was determined using the raw site scores for four of the biological metrics used by the Stream Biological Monitoring Program. These metrics are: macroinvertebrate biotic index (MBI), nutrient-organic Kansas biotic index (KBI), Ephemeroptera-Plecoptera-Trichoptera index (EPT), and percent EPT specimens with respect to total macroinvertebrate abundance (%EPTCNT). (Huggins and Moffett, 1988). A fifth metric, Total Taxa (TOTTAX), was used as a tiebreaker when other metrics were equivocal.

Support thresholds for these metrics were derived from an analysis of 44 reference streams, all sampled during the 2011-2015 assessment period (**Figure 4**). Reference were partitioned into three streamflow categories (<10 cfs, n=21; 10 to 99 cfs, n=17; and ≥100 cfs, n = 6) using 10-year median discharge estimates for the KSWR segment on which each site falls (Perry *et al.*, 2004). Probabilistic sites were assigned to these same categories using the same criteria. Within each flow category, support thresholds for the biological metrics were set at the mean values for reference populations which is a standard method for threshold setting (USEPA October 2011). This procedure effectively adjusted the expected performance of each monitored stream reach on the basis of stream size, *e.g.*, a small stream would not be expected to support the same number of EPT taxa as a large river, but it would be expected to perform as well as a similarly sized stream in the absence of environmental stressors. Support thresholds derived from this process are presented in **Table 6.** For some metrics (MBI and KBI), a higher number indicates a more degraded site; for others (EPT, %EPTCNT, TOTTAX), a lower number typically indicates a more degraded site.

Table 6. Aquatic life use non-support thresholds for biological metrics across three stream classes

Flow Group	MBI	KBI	EPT	%EPTCNT	TOTTAX +
< 10 cfs	> 4.91	> 2.86	< 6	< 30	< 34
10-99cfs	> 4.69	> 2.75	< 8	< 37	< 39
≥ 100 cfs	> 4.61	> 2.73	< 10	< 44	< 35

+ Secondary metric

Scores for probabilistic sites were compared to the flow-adjusted thresholds and assigned a value of 0 (non-support) or 1 (full support). These values were averaged across the four primary metrics to obtain a final average value for each site. If an average support value exceeded 0.5, the site in question was deemed fully supportive of the aquatic life use. If an average value was less than 0.5, the site was considered non-supportive of the aquatic life use. If an average value was exactly 0.5, the “total taxa” metric was used as a tiebreaker to determine support.

Water quality was also used to determine aquatic life support. Kansas has separate numeric water quality criteria for chronic versus acute water quality conditions as they relate to aquatic life (KDHE 2015). Data were scored against both sets of criteria. Exceedences of chronic water quality criteria for inorganic parameters were excluded if they were determined to have occurred during unstable-flow periods. Natural background concentrations of certain parameters, *e.g.*, chloride or sulfate, for individual stream segments, if applicable, were also taken into account during scoring of exceedences. (These are the same values used in approved TMDLs). If pollutant or parameter concentrations were found to exceed a given acute or chronic aquatic life criterion in greater than 25% of samples, the site in question was deemed non-supportive of the aquatic life use.

Contact Recreation Use

All probabilistic sites were assessed for recreational use support based on measured suspended concentrations of *Escherichia coli*. This bacterium is part of the normal intestinal fauna of humans and many other warm blooded animals. It is utilized in many water quality studies as a general indicator of fecal contamination. For formal (*e.g.*, 303(d)) regulatory purposes, bacteriological criteria generally are applied as geometric mean concentrations, calculated using data from at least five different samples collected in separate 24-hour periods during a 30-day assessment window (K.A.R. 28-16-28d-e). The frequency and timing of the SPMP sample collections did not meet these rigid requirements. Therefore, the results reported below for the state as a whole (*i.e.*, pursuant to section 305(b) of the CWA) were based on seasonal samples collected from each probabilistic site over the course of a single year.

Based on studies use assessment studies performed by KDHE (mostly from 2001 to 2009), each stream segment listed in the KSWR has been assigned to one of four recreational use categories, two primary and two secondary, depending on stream size, extent of public access, and other use attainability considerations (KDHE, 2012c). *Escherichia coli* data from each probabilistic site were compared to the applicable criterion concentration. Many of these sites were designated for secondary contact recreation only, in which case all available data were combined and the geometric mean was compared directly to the appropriate criterion concentration. Sites designated for primary contact recreation were evaluated with respect to recreational season (primary contact, April 1 – October 31; secondary contact, November 1 – March 31), and the geometric mean for each season was compared to the appropriate criterion concentration (**Table 7**). If the geometric mean exceeded the applicable criterion concentration during the recreation season, it was considered a "fail," and the monitoring site in question was deemed non-supportive of the recreational use.

Table 7. *Escherichia coli* criteria used in recreational use assessments

Use	Colony Forming Units (CFUs)/100mL	
Primary Contact Recreation	Geometric Mean April 1 – Oct. 31	Geometric Mean Nov. 1 – March 31
Class B	262	2,358
Class C	427	3,843
Secondary Contact Recreation	Geometric Mean Jan. 1 – Dec. 31	
Class a	2,358	
Class b	3,843	

Food Procurement Use

Of the 163 probabilistic stream sites sampled during 2010-2014, 145 fell on segments designated or proposed for food procurement and thus were regarded as viable candidates for collection of harvestable size and species of fish. However, until 2015, USEPA Region 7 laboratory analysis capacities limited sampling to about 15 sites per year. Thus, fish tissue samples were obtained from 91 of the 145 candidate sites (**Figure 4**). At each site, personnel endeavored to collect one composite (three to five fish) sample of a representative bottom-feeding fish species (*e.g.*, channel catfish, common carp) and another composite sample of an open-water predatory species (*e.g.*, largemouth bass). Through 2011, the USEPA Region 7 laboratory analyzed tissue based on composite fillet samples. In 2012, some samples were composite fillets and some were plugs. Beginning in 2012, however, the laboratory began accepting only tissue plugs for mercury. Thus, this particular assessment is based partly on fillet and partly on plug data. Non-carcinogens such as mercury are evaluated using USEPA health endpoints for chronic systemic effects. Assumptions for risk calculation included consumption of fish tissue over the duration of an average human lifetime, average adult body weight, and eight-ounce meal portions.

For measurements based on a composite sample, the following rule was used: if the composite value for either top predators or bottom feeders exceeded the threshold concentration, the site failed. For measurements based on individual plugs, the following rule was used: Both an average and a median were calculated for top predators from a given site, and these values were also calculated for bottom feeders. If any of these four values (*i.e.,* the mean or median concentration in either sample) was found to surpass the applicable threshold concentration, the site in question was deemed non-supportive of the food procurement use.

Population Extent Estimation

Data from the 163 sites assessed for aquatic life and contact recreation and from the 91 sites assessed for food procurement were used to derive estimates for the target population as a whole. If a site failed to support any single designated use, it was considered non-supportive overall. The design team at the USEPA Western Ecology Division provided the population extent and variance estimates given in this report (personal communication, Tom Kincaid and Tony Olsen). Calculations were performed using the "R" programming environment (http://www.r-project.org), the most current "sp" and "spsurvey" custom software modules (http://www.epa.gov/nheerl/arm), and the methods and assumptions of Diaz-Ramos, Stevens, and Olsen (Diaz-Ramos, Stevens and Olsen 1996, Stevens and Olsen, Variance estimation for spatially balanced samples of environmental resources 2003).

II. 305(B) AND 314 ASSESSMENT METHODOLOGY FOR LAKES AND WETLANDS

This targeted monitoring program assessed 322 publicly owned and/or publicly accessible lakes, plus a total of 36 publicly owned and/or publicly accessible wetland areas (**Figure 2**). For all chemical and physical features, the most recent six year period of record was utilized (2012 to 2017 data). For biological/trophic state features, the entire period of record was utilized so that some estimate of trends could be provided. All lakes and wetlands listed in the Kansas Surface Water Register have had use attainability analyses (UAAs) completed for all possible designated uses.

Chemical data for the six year period were subjected to a comparison to the current water quality standards to identify exceedances of those water quality standards. A lake or wetland was deemed non-supportive of a designated use if more than 25% of the samples exceeded a given criterion associated with that use, partially supportive if more than 10% (but ≤25%) of the samples exceeded the criterion, and fully supportive if ≤10% of samples exceeded the criterion. Only data from epilimnetic samples were used in the assessment.

Table 8. Mean chlorophyll-a thresholds used as support criteria for six designated uses

Support Level	Designated Use	Designated Use	Designated Use
	If Active or Emergency Public Water Supply -Domestic Water Supply[1]	-Primary Contact Recreation	-Irrigation -Livestock Watering -Secondary Contact Recreation -Aquatic Life
Fully supportive	<10 µg/L	<10 µg/L	<18 µg/L
Fully supportive but threatened	(N/A)	10-12 µg/L	18-20 µg/L
Partially supportive	(N/A)	12-20 µg/L	20-30 µg/L *or* 20-56 µg/L without blue-green algal dominance of the phytoplankton community
Non-supportive	>10 µg/L	>20 µg/L	>30 µg/L with blue-green algal dominance *or* >56 µg/L regardless of algal community composition

Biological/trophic state data were converted to a mean concentration of chlorophyll-a for each waterbody based on the period of record for that waterbody. Concentrations were compared to an existing set of thresholds used to interpret narrative standards for lake trophic state, nutrient enrichment, and turbidity (KDHE, 2005). Mean chlorophyll-a thresholds for the support of several designated uses are shown in **Table 8.**

III. 303(D) ASSESSMENT METHODOLOGY

Overview

The 2018 list of impaired (Category 5) waters builds upon listings developed in 2016. A complete description of the procedures and assumptions applied during the preparation of this list is provided by the report, "Methodology for the Evaluation and Development of the 2018 Section 303(d) List of Impaired Water Bodies for Kansas," which reflects the state's submissions as of January 31, 2018, is published at http://www.kdheks.gov/tmdl/methodology.htm.

Development of the 2018 list relied primarily on data from targeted water quality monitoring programs administered by BOW and described elsewhere in this report. The statewide water quality assessment prepared by BOW pursuant to section 305(b) of the CWA also provided initial waters for listing lakes and wetlands, and long-term routine targeted monitoring of stream chemistry and stream biology provided initial data for listing streams. BOW then performed more extensive follow-up analyses, particularly on stream chemistry and stream biology, as the final basis for identifying and listing impaired waters in Kansas.

Stream chemistry data were obtained from the statewide network of targeted permanent monitoring stations (assessment period 2000 through September 30, 2017) and rotational stations (assessment period 1990 through September 30, 2017, except toxic metals, which were assessed July 1, 2002, through September 30, 2017). To assess the chronic category of aquatic life, analysis for conventional pollutants generally used binomial techniques, adjusted to minimize Type II errors. Analysis for the aquatic life acute category or for toxics (acute or chronic), impairment is indicated by the frequency of digressions greater than once every three years.

Streams suspected of being impaired by excessive total phosphorus or total suspended solids were identified by median concentrations exceeding screening values. Table 5 in the methodology details the assessment methodology for specific pollutants based on their designated use.

Watersheds monitored by the individual stream chemistry stations comprise multiple stream segments as an assessment unit for the purposes of the 303(d) program. Waters flowing directly into some large reservoirs were not surveyed as part of the stream chemistry monitoring network, instead being assigned to the assessment unit associated with that reservoir.

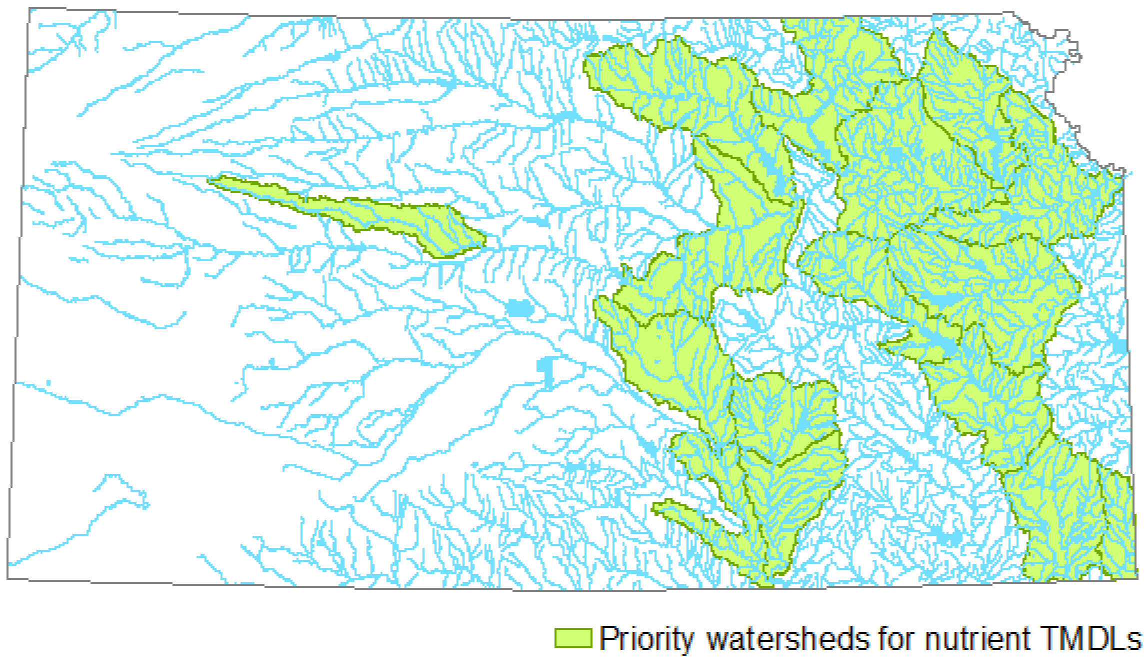
The public notice for the 2018 draft 303(d) list provides a mechanism for soliciting all readily available and existing water quality data from other agencies. In most cases, any submitted data corroborated the conclusions reached from the corresponding KDHE data. The public comment period ended March 23, 2018. No comments were received from the public which required modification of the list. The final 303(d) list, submitted to USEPA, effective March 30, 2018, identifies 498 station/pollutant Category 5 water quality impairments encompassing approximately 2,437 stream segment/pollutant combinations.

Priorities and Schedules; Introduction of the Kansas TMDL Vision

From 1999 to 2013, TMDL development efforts in each of the state's 12 major river basins have adhered mostly to a five year rotational schedule. With the emergence of a Kansas TMDL Vision, however, significant alteration in scheduling was made for the years 2014-2022, to harmonize with the approach supported by USEPA's national TMDL Program. Kansas' TMDL Vision is tied to KDHE's Nutrient Reduction Framework and places focus on streams with phosphorus or nitrate impairments within 16 HUC8s deemed as high priority, see **Figure 6.** The 2018 303(d) list identifies streams in the Smoky Hill-Solomon and Kansas Lower Republican HUC8 sub-basins with excessive total phosphorus; these are slated for TMDL development in 2018 and 2019.

Streams in other priority HUC8s will have stream phosphorus TMDLs developed in 2020-2022. As time permits, secondary impairments caused by excessive nutrients including pH, deficient dissolved oxygen, or lake eutrophication may also have TMDLs developed within the priority 16 HUC8 sub-basins. This priority schedule means that no TMDL development will be conducted in other basins of the State, particularly those in western Kansas. Additionally, current plans are that impairments other than nutrients will be deferred until the 2014- 2022 nutrient reduction TMDL work is completed. The framework for Kansas' 303(d) prioritization under the national TMDL Vision is available at: http://www.kdheks.gov/tmdl.

Figure 6. Sixteen priority watersheds for nutrient TMDL development 2014-2022



Tracking Previously Listed Waters

The 2018 303(d) list also identifies waters from previous lists that were once impaired by a pollutant (Category 5) but that are now placed in other listing categories established by USEPA. Waters with approved, established TMDLs are placed in Category 4a. Such waters in Kansas were cited as impaired on the 1998-2016 303(d) lists; these are published at: http://www.kdheks.gov/tmdl/planning_mgmt.htm. These waters remain impaired but now have a TMDL established for them, hence their removal from Category 5 to 4a.

A small number of water bodies have been designated as Category 4b, meaning their particular impairments have been addressed by some means other than development of a TMDL. Previous Category 4b waters addressed through the appropriate limits, schedules of compliance, and other conditions placed on NPDES permits are now achieving the respective water quality criteria and have been placed in Category 2, which is reserved for those Kansas waters that were once impaired, but whose water quality has subsequently been restored to meet standards. Effluent quality data from individual facility discharge monitoring records, corresponding water quality data at downstream monitoring stations, and special monitoring efforts upstream and downstream of selected facility outfalls support the transfer of those waters to Category 2.

Atrazine impairments in a limited number of water bodies in the Little Arkansas River watershed have been addressed through implementation of a WRAPS watershed plan. Continuation of Category 4b status is contingent upon ongoing efforts and results to abate atrazine loads in the selected subwatersheds of the Little Arkansas River. Because of the burden of proof placed on designated waters into Category 4b, it is unlikely that additional such entries will be made into that category. Other WRAPS groups may address impairments through implementation of their watershed plans, but the impaired waters will remain in Category 5 until those impairments are remedied or a TMDL has been established.

A few stream systems in Kansas have been designated as Category 4c, which is used for waters impaired by factors other than pollutants (such as slurry spills, habitat limitations, or flow alterations). Biological impairment as defined by macroinvertebrate monitoring appears to be linked to pervasive low flows during drought, perhaps exacerbated by water diversions. The impairment is better suited for management through water allocation and water rights administration.

Category 3 is used by Kansas when there is uncertainty as to the impaired status of a given water body. Insufficient data exist to determine if the water is newly impaired, now restored, or continues to be impaired. Relatively new stations with small sample sizes would be placed in this category as would previously impaired waters that now are just barely compliant under the applicable analysis using recent data. Additional monitoring and subsequent analysis in coming listing cycles will move waters from Category 3 into Categories 2, 4a or 5.

Waters are placed in Category 2 as a result of successful restorative implementation, updated data, changes in water quality criteria, or the removal of certain designated uses through the Use Attainability Analysis process. In some cases, corrective actions on point and non-point sources of the pollutant have improved conditions to restore the applicable water quality standard. Ammonia and chlordane are two pollutants that reflect cases in which point source improvements (lowered ammonia) or an outright ban (chlordane in 1988) have resulted in measureable improvements in ambient stream concentrations, fish tissue concentrations, and biological monitoring results.

Any surface water that has not been cited as impaired in the past or present is designated as Category 1, signifying that all its designated uses are being fully supported. All category assignments are recorded by KDHE in electronic databases, with the most recent revision tied to the 2018 listing process and submitted to KDHE as part of the 2018 integrated report and 303(d) listings package.

Assessment Results

I. 305(B) ASSESSMENT RESULTS FOR STREAMS AND RIVERS (PROBABILISTIC DATA)

The 2013 Kansas Surface Water Register identifies all currently classified stream segments in Kansas (KDHE, 2013c). Represented at 1:24,000 resolution, these collectively represent about 30,278 stream miles and include both perennial and intermittent waters. During prolonged droughts, some of this mileage is expected to be nonviable for sampling purposes. In addition, any given intermittent segment may not contain sampleable water at a randomly-chosen point along its length, especially during summer low-flow. Thus, the target sampling population is restricted to those reaches on classified stream segments that contain substantive aquatic habitats during the assessment period of interest. These habitats may include continuously flowing reaches, continuously wetted but non-flowing reaches, or isolated pools deemed capable of providing refugia for aquatic life.

Table 9. Probabilistic stream assessment fact sheet

Project Name	Kansas stream probabilistic monitoring program
Type of Waterbody	Stream or river
Units of Measurement	Miles
EPA Survey Design Project IDs	KS2010 and NRSA 2012-2013
Sample frame for assessment	Dec 12, 2013 edition of Kansas Surface Water Register
Designated Uses	Aquatic life, contact recreation, and food procurement +
Size of sample frame	30,278 miles for Aquatic Life 30,278 miles for Contact Recreation 22,235 miles for Food Procurement
Size of Target Population	19,284 miles for Aquatic Life 19,284 miles for Contact Recreation 16,224 miles for Food Procurement +
Percent supporting all three uses assessed	16% ± 3%
Percent failing to support at least one use	84% ± 3%
Percent nonresponse	0%
Indicators	Macroinvertebrate community assessments, water chemistry analyses, fish tissue mercury analyses, *E. coli* measurements
Assessment Date	February 19, 2018
Precision	95%

+ Food Procurement Use applies to only 73% of the Kansas Surface Water Register. For this assessment period, however, it applied to 84% of the target population. This is most likely due to the underrepresentation of headwater & intermittent streams during drought periods.

Based on combined desk and field reconnaissance, the target sampling population during the summers of 2011-2015 was estimated at 19,283 stream miles or approximately 64% of the total classified stream mileage on the KSWR. This extent was assessed for recreational and aquatic life support uses with chemical and biological data from 163 monitoring sites. As discussed previously, the food procurement use was assessed using fish tissue contaminant data from 91 sites. **Table 9** highlights some of the major features of the probabilistic sampling effort.

STREAM USE SUPPORT IN RELATION TO INDIVIDUAL DESIGNATED USES

The uses of surface water recognized in section 101(a) of the CWA correspond to the following three designated uses in Kansas: aquatic life support, recreation, and (human) food procurement (K.A.R. 28-16-28b *et seq.*). The first two uses apply in some form to all classified streams in the state. The food procurement use, on the other hand, is assigned only to a portion (73%) of the state's classified stream mileage – those rivers and streams that have been determined likely to contain edible fish of harvestable size. The Kansas surface water quality standards recognize additional uses for surface waters (**Table 10**), but support for those uses is not evaluated explicitly in this probabilistic assessment.

Table 10. Allocation of designated uses among classified streams

Designated Use	Proportion of Mileage Designated for Use +
Aquatic life support (any category)	100%
Contact recreation (any category)	~100% ++
Food procurement	73%
Livestock watering	96%
Irrigation	92%
Groundwater recharge	92%
Industrial water supply	74%
Domestic water supply	72%

+ Mileage given relative to the entire December 12, 2013 KSWR extent of 30,278 miles
++ The few streams with no formal use designation for contact recreation (<0.5% of total mileage) were assessed here using the least restrictive (class b) criteria.

Table 11 presents use support findings for individual section 101(a) uses (aquatic life support, contact recreation, and food procurement), and **Table 12** illustrates overall support as well as the overlap among support and non-support for all three uses. The indicated 95% confidence intervals were derived using a local variance estimator approach (Stevens and Olsen, 2003). Although only about 16% of mileage supported all three assessed uses, only 3% of mileage failed all three uses. Most stream mileage in Kansas supported one or two of the three assessed designated uses.

Table 11. Support of individual designated uses in streams (in miles)

Designated §101(a) Use	Total Sample Frame Extent	Total Targeted & Assessed Extent	Extent Supporting Indicated Use*	Extent Not supporting Indicated Use*	Extent with Insufficient Data
Aquatic Life	30,278	19,283	6,507 ± 580	12,777 ± 580	0
Contact Recreation	30,278	19,283	15,498 ± 505	3,786 ± 505	0
Food Procurement	22,215	16,224	10,749 ± 705	5,475 ± 710	0
ALL USES COMBINED	30,278	19,283	3,151 ± 518	16,131 ± 518	0

Note: where estimated variance appears to exceed the estimated value, the lower 95% confidence bound is actually zero. 95% confidence intervals were derived using local variance estimator approach (Stevens and Olsen, 2003) Food procurement monitoring was based on a subsample rather than an exhaustive sample, but it was assumed for extent estimation purposes that nonsampled sites were a random subset of the population and thus would not differ in quality from those where samples were taken.

Although this document reports confidence interval estimates only for 101(a) uses of the CWA, the stream water quality data do provide an opportunity to assess basic support for other uses. In particular, the two agricultural uses, Livestock Watering and Irrigation, are important to Kansas. Of the 163 sites sampled for water quality, 97% supported the Livestock Watering use, and 99% supported the Irrigation use. Excursions from those criteria involved presence of elevated fluoride and sulfate.

Table 12. Detailed account of use support for streams (in miles)

		Food Procurement Support	Food Procurement Non-support
Aquatic Life Support	Contact Recreation Support	3,152 ± 518 (16%)	1,776 ± 416 (9%)
	Contact Recreation Non-support	671 ± 245 (3%)	671 + 324 (3%)
Aquatic Life Non-support	Contact Recreation Support	8.236 ± 790 (43%)	2,423 ± 569 (13%)
	Contact Recreation Non-support	1,750 ± 482 (9%)	604 ± 294 (3%)

Note: if an estimated variance appears to exceed the estimated value, the lower 95% confidence bound is actually zero.

Causes and Sources of Stream Impairment

Likely causes and sources of non-support were determined for each probabilistic monitoring site exhibiting water quality impairments. This phase of the water quality assessment used habitat data collected on-site, water chemistry profiles, and aerial photographs along with geographical map coverages identifying watershed boundaries and water resources, point and nonpoint sources of pollution, general land use and land cover. Findings were extrapolated to the overall population of streams targeted during the 2011-2015 assessment period. Because some individual monitoring sites were subject to multiple causes and sources of impairment, there is overlap among their extents, and thus the stream mileage affected by all causes and sources is not amenable to straightforward summation.

Two major causes of non-support for streams were aquatic macroinvertebrate community metrics and mercury in fish tissue. Bacterial pathogens present a second general category of nonsupport. Directly-measured water chemistry parameters (metals, herbicides, physiochemical measurements) combine to form an additional functional stressor category; see **Table 13.**

Table 13. Major causes of water quality impairments in streams (in miles)

Cause category	Cause	Impaired Mileage	Percent
Water chemistry	pH (too high or too low)	237 ± 140	1%
	Dissolved oxygen (too low)	710 ± 245	4%
	Atrazine	3076 ± 449	16%
	Lead	473 ± 196	2%
	Selenium	1,420 ± 249	7%
Waterborne pathogens	*Escherichia coli* contamination	3,549 ± 502	18%
Biological assessment	Benthic macroinvertebrate bioassessment	11,357 ± 603	59%
Fish tissue chemistry	Mercury in fish tissue	5,475 ± 719	34% *

**as percentage of Food Procurement mileage represented in the target population (16,224 mi)*

Sources responsible for pollutant loadings and/or use impairments can be separated into five general categories. The most prevalent of these was general anthropogenic influence (*e.g.*, erosion and sedimentation, atmospheric deposition of contaminants), followed by identifiable agricultural influences (from both crop and livestock production), and other factors (including natural sources and unknown sources). Urban influences (both point and nonpoint) comprised a relatively minor source of use nonsupport; see **Table 14.**

Table 14. Major sources of water quality impairments in streams

Source Type	Source	Impaired mileage	Percent
Agricultural	Agricultural return flows	710 ± 207	4%
	Animal feeding operations	2,366 ± 416	12%
	Aquaculture	118 ± 106	1%
	Crop production	3,786 ± 491	20%
	Grazing in riparian or shoreline areas	2,248 ± 421	12%
Urban	Municipal point source discharges	355 ± 172	2%
	Residential districts	946 ± 273	5%
	Unspecified urban stormwater	118 ± 106	1%
General anthropogenic	Accidental release or spill	118 ± 103	1%
	Atmospheric deposition	3,549 ± 490	22% *
	Channelization	1,183 ± 314	6%
	Dam or impoundment	946 ± 266	5%
	Erosion and sedimentation	3,786 ± 492	20%
	Mining	118 ± 97	1%
	Petroleum or natural gas activities	355 ± 178	2%
	Releases from waste sites or dumps	118 ± 100	1%
Natural	Freshets or major flooding	118 ± 102	1%
	Natural sources	1,065 ± 262	6%
Other (unknown whether natural or anthropogenic)	Insufficient instream habitat	946 ± 285	5%
	Reduced stream flow	237 ± 148	1%
	Source Unknown	3,904 ± 505	20%

**as percentage of Food Procurement mileage represented in the target population (16,224 mi)*

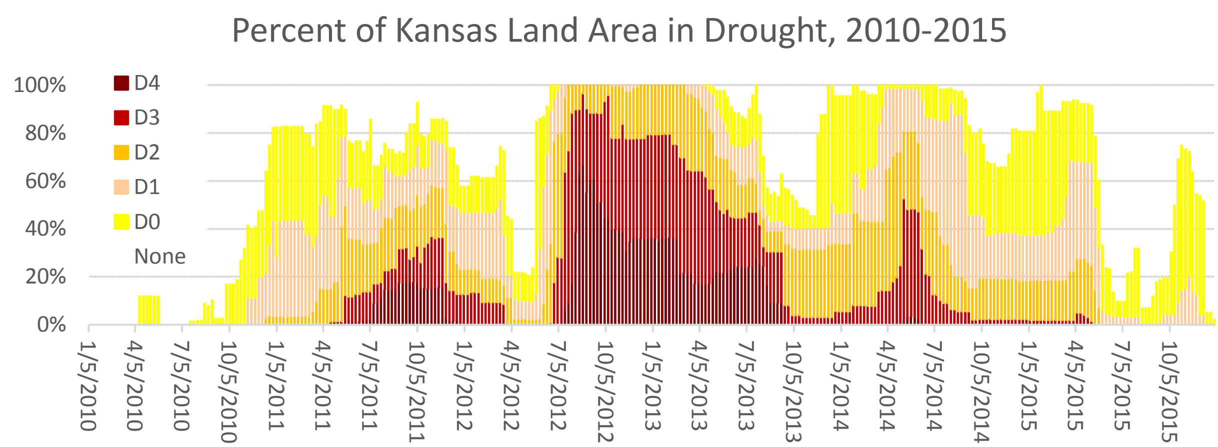
Kansas suffered from significant drought for over half of the monitoring period reported here. The drought of 2012-2013 was particularly severe. For several months, 100% of the land area of Kansas was under severe to exceptional drought Error! Reference source not found.**)** (National Oceanic and Atmospheric Administration 2016).

What follows is a summary of Kansas Annual Drought Reports from 2010 to 2015 (Kansas Water Office 2010-2014) and related data (Diane Knowles, Kansas Water Office, pers. comm. January 2016 and February 2018):

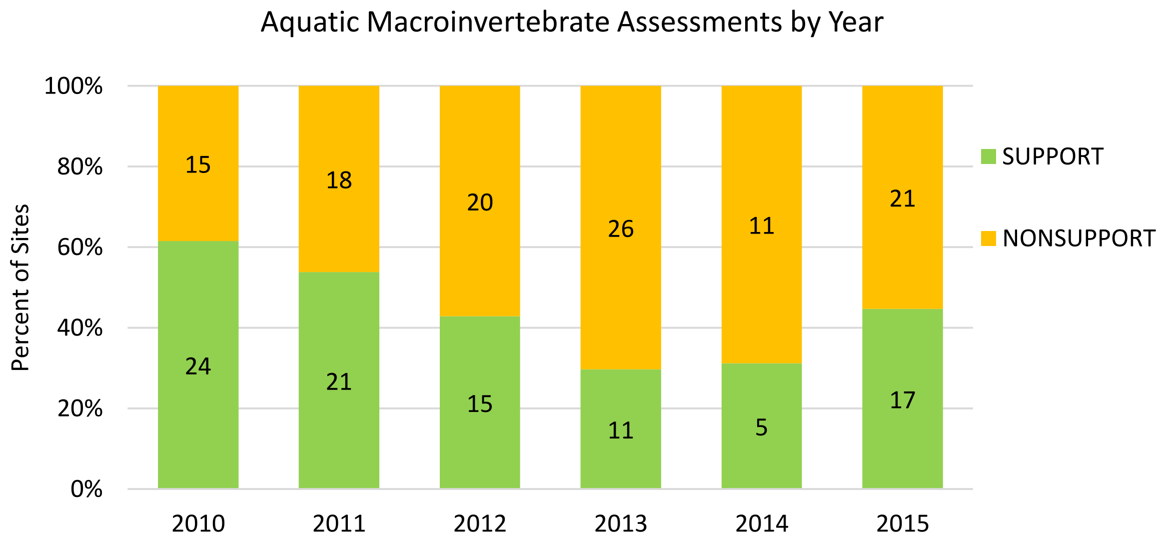
- In 2010, statewide precipitation was 103% of normal, but this was not distributed normally. There was flooding in some areas, but by fall, 82% of the state was in at least moderate drought.
- In 2011, statewide precipitation was 89% of normal; the drought worsened overall in intensity and extent, with severe to exception drought in the southwest; some emergency water conservation and use plans were initiated.
- In 2012, statewide precipitation was only 71% of normal, and the entire state was in severe to exceptional drought, with a number of grass fires. The entire state was in drought emergency state from July 2012 to August 2013.
- In 2013, precipitation was 106% of normal, but it arrived during summer, rather than spring and fall. The western part of the state remained in drought, but conditions improved somewhat in the east.
- In 2014, statewide precipitation was 95% of normal, but streamflows were still below normal for all but the eastern part of the state.

- In 2015, statewide precipitation was 113% of normal, and USGS characterized streamflow as normal for the year, with higher than usual spring flows compensating for lower than usual winter flows.

Figure 7. Percent land area of Kansas affected by drought, 2010-2015
Sampling period was 2011 to 2015. Data extracted from the United States Drought Monitor website, droughtmonitor.unl.edu. Author: Brian Fuchs, National Drought Mitigation Center. Color coded for severity: Yellow: D0 (Abnormally Dry) / Peach: D1 (Moderate Drought) / Orange: D2 (Severe Drought) / Red: D3 (Extreme Drought) / Maroon: D4 (Exceptional Drought).



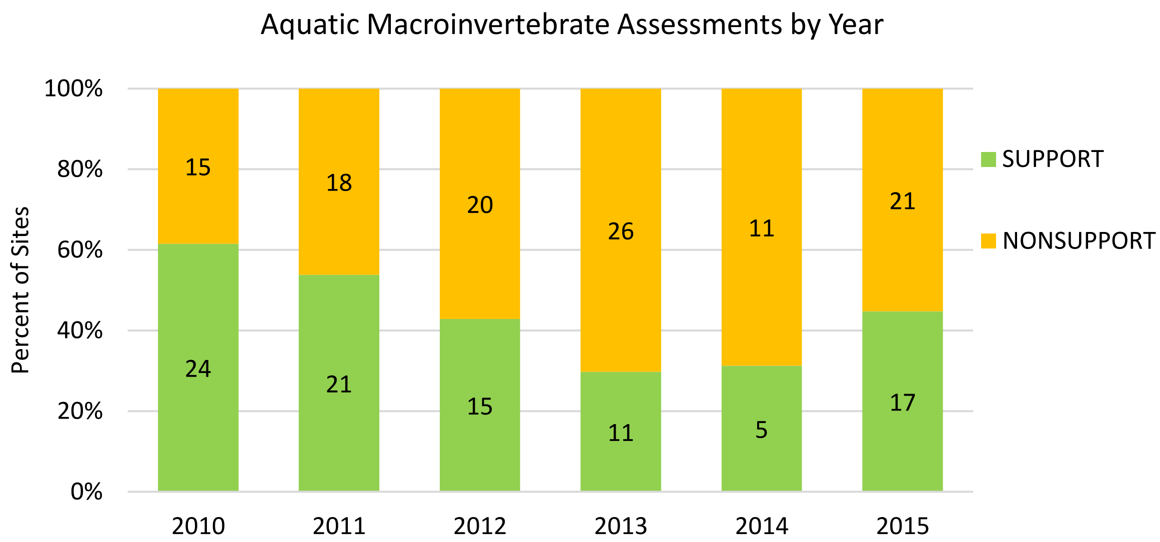
Streamflow is affected by both surface runoff and subsurface/groundwater flow, and these lag precipitation events by varying time frames. If a stream has been scoured by flooding or dried by drought, recolonization by aquatic communities also requires time. Even so, these severe weather events appear correlated to the condition of aquatic macroinvertebrate communities (**Figure 8.** Aquatic macroinvertebrate assemblage health, shown by sample year.



).

It is thus surmised that the drought and other weather-related events contributed to many of the stream impairments documented during this period.

Figure 8. Aquatic macroinvertebrate assemblage health, shown by sample year.



Site count is shown in bars; Y axis shows relative proportions of sites passing or failing the screening-level assessment.

Although this assessment indicates that many stream systems may be in suboptimal or impacted condition, it also suggests that they have capacity for recovery when streamflow conditions return to normal. Mitigation of major identifiable stressors could also result in restored stream health and greater resilience.

II. 305(B) AND 314 ASSESSMENT RESULTS FOR LAKES AND WETLANDS

Lakes Assessment

Background

A total of 322 publicly owned or publicly accessible lakes are included in this reporting cycle. This represents all registered lakes known to KDHE through monitoring activities, as well as from sources published by other agencies, most notably Kansas Department of Wildlife, Parks and Tourism (KDWPT) and the US Army Corps of Engineers (USACE). These lakes comprise an estimated total of 190,445 acres of surface area at normal conservation pool levels. Lakes with their shorelines under common private ownership are considered private lakes in Kansas, but may still be public waterbodies under state water quality standards if they supply public drinking water or are open to the general public, by invitation or fee, for recreational use.

For the purposes of this report, all publicly owned/accessible lakes, reservoirs, and ponds are referred to as “significant” public waterbodies. This is based on the assumption that any lentic waterbody that is owned by, or accessible to, the general public will provide benefits to the general population. These benefits may include recreation and water supply, but will also certainly include habitat for the support of indigenous aquatic and semi-aquatic organisms, including fish and migratory waterfowl.

Unless specifically identified as a wetland, all lentic waterbodies are referred to as “lakes” within this report, regardless of size or origin. This is done in order to avoid the arbitrary thresholds separating ponds from other waterbodies, and to recognize the fact that we assign and expect the same benefits from constructed lakes as we do from naturally formed ones.

Impaired and Threatened Lakes

Table 15 presents a comparison of lake acreage assessed for this 305(b) reporting cycle versus the means by which Aquatic Life Use Support (ALUS) assessments were determined. Assessments utilize a period of record of six years for physical/chemical data and the entire period of record for trophic state data for trends. At all monitored lakes, surveys include biological, chemical, and physical data components, which also factor into metrics related to habitat. Monitored sites are those that have sampling events in multiple years with at least one event occurring within the most recent six-year time period. Evaluated sites are those with all chemical sampling occasions occurring prior to the most recent six-year sampling. An additional 12 classified lakes comprising 1,375 acres are included in this assessment, but have no trophic state data and no recent (6-year) physical/chemical assessment. The majority of lake acreage is monitored, as can be seen in **Table 16**.

Table 15. Categories of data used in ALUS assessments for lakes (in acres)

Degree of Aquatic Life Use support (acute criteria)	Acres assessed using only biological data	Acres assessed using only chemical data	Acres assessed using biological and chemical data	Acres assessed
Insufficient Data				1,375
Fully Supported	3,931	0	110,531	114,462
Fully Supported but Threatened	184	0	6,190	6,374
Partially Supported	718	0	38,881	39,599
Not Supported	840	0	27,795	28,635
Total acres	5,673	0	183,397	190,445

Table 16 summarizes overall use support ratings for lakes assessed during this 305(b) cycle.

Table 16. Summary of Fully Supporting, Threatened, and Impaired Lakes

DEGREE OF USE SUPPORT	Assessment Category		Total acres
	Evaluated	Monitored	
Insufficient Data			1,375
Fully Supporting of All Uses	1,838	2,708	4,546
Threatened for One or More Uses (But Not Impaired for Any Uses)	1,048	52	1,100
Impaired for One or More Uses	2,787	180,637	183,424
Total Size Assessed	5,673	183,397	190,445

Table 17 divides assessments into specific beneficial uses. Fully 96% of reported lake acres are

considered to be monitored and, thus, are monitored for "toxics" such as heavy metals and pesticides as well as the other inorganic and biological parameters common to KDHE lake surveys. Of the 183,397 monitored lake acres, 6,186 acres (3.4%) show some level of impairment from heavy metals and/or pesticides.

Table 17. Individual use summary for lakes (in acres)

Goals	Use	Size Assessed	Fully Supporting	Fully supporting but threatened	Partially Supporting	Non Supporting	Insufficient Data
Protect and Enhance Ecosystems	Aquatic Life (acute criteria)	190,445	117,609	6,606	26,794	38,061	1,375
Protect and Enhance Public Health +	Fish Consumption++	190,445	188,314	0	530	33	1,568
	Primary Contact	190,317	43,656	1,101	114,576	29,710	1,274
	Secondary Contact	190,436	152,740	6,606	20,292	9,423	1,375
	Domestic Water Supply	188,924	26,002	914	35,806	124,976	1,226
Social and Economic Enhancement +	Irrigation	190,077	152,646	6,153	20,292	9,772	1,214
	Livestock Water Supply	190,092	145,635	6,606	27,878	8,747	1,226

+ = Shellfishing and Cultural Use categories not applicable
++ = Based on food procurement criteria for water

Table 18 presents information related to direct and indirect causes of water quality impairments for this reporting cycle, and **Table 19** presents similar information regarding sources. Causes (or Observed Effects) are the most applicable ATTAINS categories listed.

Table 18. Total lake area impacted by various cause categories (in acres)

CAUSE CATEGORY AND CODES	CONTRIBUTION TO IMPAIRMENT	
	MAJOR	MODERATE/MINOR
Pesticides - atrazine	402	0
Heavy Metals – arsenic	66	1,074
Heavy Metals – copper	130	0
Heavy Metals – lead	1	2,875
Heavy Metals – selenium	0	6,800
Heavy Metals – mercury	0	530
Fluoride	450	205
Nutrients and Eutrophication	37,583	104,519
High pH	158	26,207
Low pH	0	10
Siltation and Turbidity	33,807	18,067
Low Dissolved Oxygen	100	573
Chloride	0	12,548
Sulfate	257	36,875
Flow Alterations	0	17,860
Aquatic Plants	2	263
Zebra Mussels	12,964	115,899

For the most part, the results for this reporting cycle are very similar to the results reported in past 305(b) cycles. Nutrient and eutrophication related impacts dominate the list of water quality problems, along with secondary effects of eutrophication, with agriculture, urban runoff, natural sources, and point source nutrient loads being the most dominant sources.

Invasive zebra mussels (*Dreissena polymorpha*) have continued to expand into additional lakes in Kansas over the last two years. Twenty-eight lakes (as of December 7, 2017) now have documented populations, totaling 128,863 acres or 68% of reported lake acreage. This is roughly double the infested lake area reported in the 2010 305(b) report, and 3.5 times that reported in the 2008 305(b) report, which was the first 305(b) to document zebra mussels in the state.

Natural sources refer primarily to climate and weather driven impacts (such as water depletion from drought, wind resuspension of sediments, and shallow thermal stratification) or naturally high salinity in some locales. Natural sources account for virtually none of the nutrient and eutrophication or heavy metal related impacts in Kansas lakes.

Table 19. Total lake area impaired by various source categories (in acres)

SOURCE CATEGORY AND CODES	CONTRIBUTION TO IMPAIRMENT	
	MAJOR	MODERATE/MINOR
Municipal Point Sources	25,600	120,691
Agriculture	36,251	120,991
Urban	955	7,664
Resource Extraction	0	899
Hydromodification	3,619	7,127
Natural Sources+	220	28,649
Resuspension	10,828	255
Introductions of Non-Native Organisms	12,966	115,899

+ Refers mainly to climate and drought impacts plus background levels of salinity and fluoride.

Table 20 lists the numbers and acreage of lakes impacted by nonpoint and/or point sources of pollution, plus those with no identified impairments. Although nonpoint source impairments impact more of the smaller lakes, most of the largest lakes in Kansas have both point and nonpoint sources present within their watersheds.

Table 20. Lakes with identifiable point and nonpoint source pollution contributions

Pollution Type	Number of Lakes	Acres of Lakes
Point Sources +	24	146,291
Nonpoint Sources +	246	176,728
No Identifiable Pollution Sources	66	12,205

+ Numbers include any level of point source contribution, and any magnitude and combination of nonpoint source pollution impacts. Due to the fact that lakes may have both source types within their watersheds, numbers will not sum to match the total number or acres assessed.

Related to the predominant impact that nutrient pollution and the resulting eutrophication process has on lake use support, a recurring activity within KDHE has been the description of what are generally referred to as "reference" trophic state conditions for lakes in Kansas. In essence, reference water quality conditions for lakes occur in watersheds with limited human activity and anthropogenic pollution loads. These "least impacted or better" waterbodies then describe the condition that would be generally attainable if polluting activities were reduced, well buffered, or otherwise mitigated in the general population of lakes and wetlands. Thus, reference condition provides a valuable and attainable water quality goal for a given class of waterbodies.

Based on the water quality and trophic state data collected since the 1970s for lakes in Kansas, the following general conclusions regarding reference trophic state conditions have been reached. Lakes in Kansas with minimal pollution loads can be expected to achieve mesotrophic-to-slightly eutrophic conditions (chlorophyll-a of under 10 to 12 µg/L), with low total nutrient concentrations (total phosphorus below 30 to 35 µg/L) and relatively high water clarity (Secchi depth deeper than 1.25 to 1.50 meters) (Carney 2009, Dodds, Carney and Angelo, Determining ecoregional reference conditions for nutrients, Secchi depth, and chlorophyll-a in Kansas lakes and reservoirs 2006). For this 305(b) cycle, 11.5% of monitored lakes (comprising about 20% of assessed surface area) achieve "least impacted or better" status for nutrient levels and trophic state condition.

Trophic Status

Trophic state classification for Kansas lakes and wetlands is based primarily on the period of record for observed chlorophyll-a (corrected for phaeophytin-a). The rationale is based on the idea that planktonic algal biomass, as estimated by chlorophyll-a, comprises the vast majority of the base of the typical lacustrine food web in Kansas. Although macrophyte communities do contribute to the overall biological production in our lacustrine food webs, it is very rare that they provide a large portion of that food web base in and of themselves. A more typical situation would be a large macrophyte community providing structure so an increased epiphytic and benthic base for a food web could arise. Because of this, and the fact that absence of macrophyte beds is a far more common concern for the water quality and health of Kansas lakes, adjustment of trophic state classification due to macrophyte beds is rare.

The observed level of chlorophyll-a provides a very good estimate of overall lake productivity and production. In addition, higher levels of planktonic algal biomass correlate well with lower levels of aesthetic appeal and recreational opportunity, increasing costs for producing drinking water, and increasing problems for using lake water for livestock and irrigation (Dodds, Bouska, et al. 2009, Lardner, et al. 2005, Willms, et al. 2002). Because of these factors, the trophic state estimate also becomes valuable for assessing levels of overall support for lakes and wetlands in Kansas.

Whereas higher levels of sedimentation are often concurrent with the eutrophication process in the Midwest, KDHE monitoring does not allow more than a rough indication of sedimentation impacts per se. For the majority of settings, sedimentation is inferred from shoreline and inflow area observations, as well as watershed land use configuration, and the general turbidity of a system. Where high turbidity seems a chronic problem, trophic state may alternately be assigned using total nutrient concentrations and turbidity levels.

Chlorophyll-a values are converted to a trophic state class assignment based on the mean period of record value for a given lake or wetland. The following scale is used in assigning a lake to a given class. The TSI score is that of Carlson (Carlson 1977), based on chlorophyll-a **(Table 21).**

The four primary classes are Oligomesotrophic, Mesotrophic, Eutrophic, and Hypereutrophic. The Eutrophic class is divided into three sub-classes, in order to better describe expected levels of use impairment. Likewise, the hypereutrophic class is divided into two sub-classes for the same reason. In the case of the Hypereutrophic sub-classes, the dominance, or lack thereof, for blue-green algae (cyanophytes) also factors into use support assignments.

In addition, two supplemental trophic state classes are used for lake and wetland assignments; Argillotrophic and Dystrophic. An Argillotrophic waterbody is chronically light limited and nutrient rich, resulting in artificially low algal biomass and chlorophyll-a. A Dystrophic waterbody is highly colored by humic/organic dissolved matter, resulting in potentially lower than expected chlorophyll-a. Dystrophic lakes in Kansas are very rare. **Table 21** presents lake trophic state designations for this reporting cycle.

Table 21. Trophic status of lakes during this reporting cycle

Trophic status	TSI+	Number of Lakes (number and percent total)		Lake Surface Area (acres and percent total)	
Argillotrophic		8	2.48%	22,032	11.57%
Oligomesotrophic	< 40	14	4.35%	407	0.21%
Mesotrophic	40 – 49.99	38	11.80%	12,848	6.75%
Slightly Eutrophic	50 – 54.99	50	15.53%	53,002	27.83%
Fully Eutrophic	55 – 59.99	63	19.57%	71,727	37.66%
Very Eutrophic	60 – 63.99	44	13.66%	19,264	10.12%
Lower Hypereutrophic	63.99 – 69.99	45	13.98%	7,944	4.17%
Upper Hypereutrophic	>69.99	48	14.91%	1,846	0.97%
Dystrophic		0	0.00%	0	0.00%
Unknown		12	3.73%	1,375	0.72%
Totals		322	~100%	190,445	~100%

+Trophic State Index (TSI) is based on chlorophyll levels and derived from Carlson (1977)

The greatest portion of individual lakes fell into the slightly-to-fully eutrophic and the hypereutrophic classes, whereas the greatest amount of surface acres were within the slightly-to-fully eutrophic and the argillotrophic classes. This difference primarily results from the skewed size range of Kansas lakes. The vast majority of lakes are smaller (and often shallower) systems, which may be more impacted by pollution sources (on a watershed acre-to-lake acre basis) than larger systems might be. Also, several of the larger Federal lakes in Kansas are located on rivers that tend to move a great deal of eroded sediment. Therefore, several of the largest lakes in Kansas are chronically turbid and assigned to the argillotrophic class.

Whereas roughly 4% of lakes reported for in this cycle lack data for assigning a trophic state class, they comprise <1% of the total reported acres. Some of these lakes are frequently dry systems, making long-term trophic classification problematic.

Trends in Lake Water Quality

Time trends in lake water quality in Kansas are difficult to determine for individual lakes, due to the programmatic emphasis on regional and statewide assessment rather than in-depth studies at specific waterbodies. Trophic state remains the best means to examine trends in overall lake water quality, much as trophic state was earlier identified as a good overall water quality indicator for our lakes. Trends indicated in **Table 22** are very general in nature. If a lake had three or more trophic state assessments over the years, a trend was assigned as follows:

If there was a strong upward direction in trophic state over time, the lake was assigned to the "degrading" category. If there was a strong downward direction in trophic state over time, the lake was assigned to the "improving" category. Lakes were assigned to the "stable" category for two different sets of conditions. First, if trophic state assessments did not change much with time or, second, if they varied to the extent that any obvious trend was masked. Otherwise, lakes were assigned to the "unknown" category if they had no data available, or if they had fewer than three trophic state assessments over the period of record.

A majority of lakes fell into the unknown category, but these only comprise about 3% of the total surface acreage. Of the remaining lakes, most were in the stable category. However, the 39 lakes with degrading trophic status account for 34% of the total lake acreage. Very few lakes showed an improving trend in trophic status.

Table 22. Trophic state trends in lakes

Category	Number of Lakes		Surface Area of Lakes	
	Count	% Total	Acres	% Total
Improving	7	2.17%	698	0.37%
Stable	121	37.58%	118,603	62.28%
Degrading	39	12.11%	65,215	34.24%
Trend Unknown	155	48.14%	5,929	3.11%
Totals	322	~100%	190,445	~100%

Control Methods

Control methods for preventing or reversing pollution problems in Kansas lakes, as provided by KDHE, are primarily limited to the provision of technical advice and limited technical support, Section 319 grants aimed at citizen education and watershed best management practice (BMP) implementation, or guidelines for constructing or managing water supply lakes.

KDHE Bureau of Environmental Field Services (BEFS) and, now, Bureau of Water (BOW) have operated a technical assistance program for taste and odor problems in water supply lakes since 1989. Over 250 specific investigations have been undertaken as of 2017, dealing with water supply taste and odor problems, algae bloom concerns, fish kills, and other nuisance and public health concerns. Most such investigations are aimed at providing taxonomic assistance to water suppliers and lake managers. As of 2010, KDHE adopted a policy formalizing the response to algae bloom complaints and investigations in regards to public health. Since then, 104 lakes have been investigated for algae bloom related complaints.

In-depth lake sampling and restoration projects at specific lakes in the past were dependent on the Section 314 Clean Lakes Program grants. With those roles now being transferred to Section 319 Nonpoint Source programs, in-depth lake assessment projects and restoration projects have been reduced in scope if not number. In the past, matching effort from the many smaller communities in Kansas was a constant challenge for Clean Lakes Program projects. This problem is, if anything, more pronounced today.

The KDHE Bureau of Water (BOW) does maintain a statewide monitoring program for lakes and wetlands for the purposes of making statewide and regional assessments of overall lake water quality in Kansas. This network operates in order to comply with Federal requirements and expectations under the Clean Water Act as well as serve state and local needs for information and technical assistance. This network has been in place since 1975, with wetlands first added in 1988. The network strives to provide a near-census for publicly owned/managed lake surface acreage in the state. The water quality data collected to date has been used to develop numerous water quality models that serve as valuable lake management tools, develop numerous TMDLs, and provide a basis for determining statewide water quality conditions and trends.

The Kansas Department of Wildlife, Parks and Tourism (KDWPT) provides assistance and technical advice to lake managers and citizens, with the emphasis on fisheries management rather than overall lake water quality. Some practices, such as the use of grass carp (*Ctenopharyngodon idella*) for plant control, or aeration/destratification, often run counter to maintaining the overall water quality within lakes.

Restoration and Rehabilitation Efforts

Several restoration techniques have been applied in Kansas, but most instances are not documented in a fashion that makes such information readily available. Therefore, only restoration actions specific to projects directly involving KDHE, or higher profile projects primarily involved with other agencies, are discussed within this report.

Some of the most common activities, perhaps dubiously referred to as rehabilitation techniques by many, involve the use of copper sulfate for algae control and grass carp for macrophyte control. Although such activities are sometimes warranted, KDHE has tended to discourage the use of either practice as a prophylactic treatment. Copper sulfate should only be used for algae control if monitoring does show a strong need, and amounts should be applied with the full knowledge that copper will accumulate in the sediments. Grass carp, due to their impact on trophic state and water quality, should not be used for macrophyte control unless aquatic plants produce lake-wide problems to lake users and no other option is feasible. Additional effective methods for algae control are being explored by both public and private sector researchers.

Fortunately, there are now available at least two aquatic herbicides registered for use in Kansas with selective control capabilities for Eurasian watermilfoil (*Myriophyllum spicatum*) and other dicotyledonous aquatic species. As Eurasian watermilfoil continues to expand into lakes throughout Kansas, the use of these new herbicides (fluridone and triclopyr) may supplant grass carp as the preferred plant control technique. Roughly 15-20% of monitoring network lakes have Eurasian watermilfoil present at varying levels of abundance. As stated elsewhere, the lack of macrophyte beds is a far more common problem for maintaining healthy lakes in Kansas, rather than lakes with excessive macrophyte growth. Therefore, any technique that might allow native macrophyte species to be maintained or encouraged, while dealing with more invasive species, is welcome.

KDWPT is involved in lake restoration and rehabilitation for the primary purpose of fisheries management for recreation. Techniques such as recycling brush and Christmas trees for fish habitat are also common. Water level fluctuations are utilized to manage fish spawning habitat as well as waterfowl habitat. KDWPT annually submits water level adjustment plans for many of the federal lakes in Kansas to the Kansas Water Office (KWO), which are reviewed and commented on at public meetings prior to submission to the USACE.

Aeration has become a common technique applied to smaller Kansas lakes in the attempt to control eutrophication. Unfortunately, almost all these efforts are undertaken without adequate study to determine whether aeration or destratification will positively impact lake water quality. Likewise, follow-up monitoring is typically limited to anecdotally observing a neutral-to-negative impact, followed by abandonment of the technique, or similarly observing a neutral-to-positive impact and continuing the technique into the future, whether or not it has had any measurable impact that could be definitively attributed to the technique. KDHE has strongly recommended to lake managers that aerators only be purchased and applied once a lake study has definitively shown aeration might improve water quality, versus other techniques.

The application of BMPs continues to be the most common and useful means of lake restoration and rehabilitation in Kansas. BMPs can cover a wide range of practices for both agricultural and urban lands. Some of the more common techniques include vegetated buffer strips along streams and shorelines, runoff diversion, pre-treatment impoundments, improved cropping/fertilization practices, sediment retention ponds, and treatment wetlands. Most BMP installation is via the Natural Resource Conservation Service (NRCS) and local Conservation Districts, in cooperation with KDHE and/or KWO.

Wastewater National Pollutant Discharge Elimination System (NPDES) and confined animal feeding operation (CAFO) permits are sometimes used to promote lake water quality restoration. Downstream impacts from such permitted facilities can be taken into account in the permitting process, and during public participation activities for such permits, regarding their limits on specific water quality parameters in effluents.

Dredging has also been an infrequent, and expensive, means to attempt to restore smaller lakes in Kansas. Dredging projects, due to the expense, have been few in number over the years. Such efforts have been even more infrequent since the Section 314 Clean Lakes Program ceased funding Phase 2 project grants through the Section 314 program specifically. One significant exception is the $20M project to dredge three million cubic yards of sediment from a portion of John Redmond Reservoir. The project was planned for many years and executed in 2016. Among other functions, John Redmond provides flood control to the area and water supply to 19 surrounding communities and six industrial users, including the Wolf Creek Nuclear Operating Station.

Since the transfer of lake protection and restoration grants to the Section 319 Nonpoint Source Pollution Program, watershed land treatment has become emphasized over in-lake restoration at the state funding level. Any discussion of specific Section 319 projects will be listed in that section of this report.

Acid Effects on Lakes

A total of 183,397 acres of lakes in Kansas were monitored for pH, accounting for 96% of the total reported acres for this report cycle. Water quality impacts in Kansas resulting from pH levels, as seen in the data presented in Table 18**,** are almost totally due to higher pH values attained when lakes are over-enriched with nutrients and suffer from eutrophication and a high trophic state. For this report cycle, only one lake had a pH below 6.5 units.

Even for the Mined Land Lakes Recreation Area units, where past coal mining makes them “likely” sites for low pH problems, such problems are few and far between. Enough time has passed since these areas were actively mined, and many have also been sporadically treated with lime additions, so that low pH problems are almost non-existent. Anecdotal evidence, from conversations with some citizens in southeast Kansas, suggests maybe a number of privately owned strip pit lakes still have chronically low pH, but KDHE has no specific data to confirm this. As most of the private strip pit lakes are as old as the public units, it is anticipated that the majority of them also show moderation of their pH ranges as they have aged.

The lack of an extensive Kansas problem with acidification stems from our regional geology. Kansas is underlain with abundant limestone bedrock, and soils derived from that limestone. Therefore, our state has a built in defense against atmospheric deposition of acid materials, or most other sources of acidic conditions. Other than the always possible, yet localized, chance of a spill of acidic material, the only significant sources for such water quality problems lie in past coal mined areas, or shale quarries, in Kansas. As shown by the pH data KDHE has collected throughout this region of southeast Kansas, such problems are mild and infrequent today.

Wetlands Assessment

Extent of Wetland Resources

The wetland area reported for this 305(b) cycle is 55,969 acres. This includes state and federal public wetland areas in Kansas, plus several that are owned or managed at the local level. This total does not include privately owned wetland areas, which likely comprise a larger total surface area in the state.

At present, Kansas does not have the data for a precise estimate of wetland loss from historic levels or for the current wetland area extant in the state. Several studies have been conducted in the past, but many have assumptions, based on their primary study purpose, that render them less useful for providing numbers related to total wetlands in Kansas. One of the better studies was that of Dahl (1990), which suggested that by the 1980s the conterminous United States had lost roughly 53% of its wetlands whereas Kansas had lost 48%. This suggests that our wetland loss is similar to the general estimates for the United States at about 2% per year.

The Dahl (1990) study suggested that historical wetland area in Kansas was around 841,000 acres total. A 1992 Wetland Rapid Assessment Procedure (WRAP) study by the Kansas Water Office (Kansas Water Office 1993) also suggested that total wetland area in Kansas, as of the 1980s, totaled around 435,400 acres, which is fairly consistent with estimated losses from historic levels from the Dahl study. Applying the 2% per year general loss rate to the USFWS value, perhaps 215,000 to 265,000 acres of wetlands still exist in Kansas. If accurate, the majority of extant wetlands in Kansas are on private lands.

No estimates are available that differentiate the wetlands in Kansas among various wetland types, however, field observations suggest the majority of Kansas wetlands are palustrine freshwater marshes, palustrine saltwater (oligohaline) marshes, riparian wetlands, playas, and wet meadows.

Integrity of Wetland Resources

Of the 55,969 wetland acres (36 wetlands) assessed during this reporting cycle, 40,833 acres (9 wetlands) are considered to be monitored sites. This represents 73% of the reported acreage. An additional 13 wetlands comprising 1,531 acres are reported as evaluated. A total of 13,605 acres (17 wetlands) were assigned to the unknown category due to insufficient data. In most cases, "insufficient water quality data" resulted from the intermittent nature of standing water in wetlands (regarding both availability and depth) from which representative water samples might be collected. Many of these areas above major federal lakes are filled seasonally for fall and winter recreation, and frequently are dry during the summer sampling period.

Wetlands in Kansas have had use attainability analyses (UAAs) completed for the range of designated uses, but the primary functions of wetlands in Kansas are as aquatic life support and recreational sites. Therefore, only those specific individual uses are reported in **Table 23.**

Table 23. Individual use summary for wetlands (in acres)

Goals	Use	Size Assessed	Fully Supporting	Full Support But Threatened	Partially Supporting	Non Supporting	Insufficient Data
Protect and Enhance Ecosystems	Aquatic Life (acute criteria)	55,969	104	0	1,391	40,869	13,605
Protect and Enhance Public Health+	Fish Consumption++	55,969	26,191	0	2,240	13,933	13,605
	Secondary Contact	55,969	104	0	1,391	40,869	13,605

+ = Shellfishing use category not applicable and thus not reported
++ = Based on food procurement criteria for water

Table 24 presents data on the causes of use impairment in wetlands. The primary causes of wetland use impairment for this 305(b) cycle are over-enrichment and extreme trophic state conditions and elevated pH levels due to these extreme conditions. Arsenic was detected in a sample from one of the state's largest wetlands, and could be the result of the wetland recently re-filling and exiting a severe drought period.

Table 24. Total wetland acres impacted by various cause categories (in acres)

CAUSE CATEGORY AND CODES	CONTRIBUTION TO IMPAIRMENT	
	MAJOR	MODERATE/MINOR
Pesticides - atrazine (148)	0	3,295
Heavy Metals – arsenic (145)	13,933	2,240
Heavy Metals – lead (663)	0	1,175
Heavy Metals – selenium (984)	0	1,265
Nutrients and Eutrophication (483 and 746)	23,649	18,493
Chloride (272)	0	35,933
Sulfate (1016)	0	28,398
High pH (620)	13,200	3,505
Flow Alterations (546)	0	13,933

Table 25 presents data on the sources of use impairment in Kansas wetlands. The major sources of wetland use impairment are agricultural runoff, hydrologic modifications, and natural processes. Natural sources refer primarily to climate and weather driven impacts (such as water depletion from drought) and naturally high salinity in some locales. Natural sources account for virtually none of the nutrient/eutrophication or heavy metal related impacts in Kansas wetlands.

Table 25. Total wetland acres impacted by various source categories

SOURCE CATEGORY AND CODES	CONTRIBUTION TO IMPAIRMENT	
	MAJOR	MODERATE/MINOR
Municipal Point Sources (3)	4,572	13,934
Agriculture (18)	1,555	44,141
Urban (64)	70	20
Resource Extraction (252)	0	220
Hydromodification (1)	0	36,009
Natural Sources+ (12 and 142)	0	14,934
Resuspension (205)	0	1,175

+ Refers mainly to climate and drought impacts plus background levels of salinity

During this reporting cycle, 41,895 acres of wetlands were assessed as hypereutrophic. This represents 75% of the total acreage and nearly 99% of the acreage with available data. In many cases, the degree of hypereutrophy was extreme. Certainly, the level of nutrient enrichment was far above the expectations for wetland water quality in relatively low-impact drainages (*i.e.*, "least-impacted" or better) (KDHE 2002). These numbers indicate that the vast majority of the remaining Kansas wetlands under public control and management suffer an inordinately high degree of impact from nutrient enrichment and eutrophication.

This current situation has led to the erroneous general impression that wetlands in Kansas are, as a matter of course, possessed of poorer water quality and extreme trophic state conditions. Whereas wetlands would be expected, on average, to have higher nutrients and trophic status than comparable lakes, least impacted condition for wetlands is only marginally higher than least impacted condition for lakes. **Table 26** and **Table 27** present data on wetland trophic status and gross trophic state trends for this 305(b) cycle, respectively.

Table 26. Trophic status in wetlands

Trophic status	Number of wetlands		Acreage of wetlands	
	Count	Percent of total	Acres	Percent of total
Argillotrophic	0	0.00%	0	0.00%
Oligomesotrophic	2	5.56%	40	0.07%
Mesotrophic	1	2.78%	1	<0.01%
Slightly Eutrophic	0	0.00%	0	0.00%
Eutrophic	3	8.33%	63	0.11%
Very Eutrophic	2	5.56%	365	0.65%
Lower Hypereutrophic	2	5.56%	1,026	1.83%
Upper Hypereutrophic	10	27.78%	40,869	73.02%
Dystrophic	0	0.00%	0	0.00%
Unknown	16	44.44%	13,605	24.31%
Totals	36	~100%	55,969	~100

Table 27. Trophic state trends in wetlands

Category	Number of wetlands		Acreage of wetlands	
	Count	Percent of total	Count	Percent of total
Improving	0	0.00%	0	0.00%
Stable	14	38.89%	40,633	72.60%
Degrading	3	8.33%	1,311	2.34%
Trend Unknown	19	52.78%	14,025	25.06%
Assessed for Trends	36	~100%	55,969	~100%

Development of Wetland Water Quality Standards

Wetlands are currently classified as "waters of the state" within the Kansas surface water quality standards (KDHE 2015). UAA analyses have been completed for all designated uses, and the results of these UAAs are incorporated into the Kansas surface water register. Wetlands receive equal treatment and protection with lakes, regarding application of state water quality standards for narrative and numeric criteria, antidegradation provisions, and implementation procedures. The US Environmental Protection Agency (USEPA) has proposed wetland specific biocriteria, but the development of such biocriteria is not considered feasible at this point in time.

Additional Wetland Protection Activities

Wetland protection tends to be distributed among agencies in Kansas, with no agency having a primary function for all aspects of wetland management. Kansas Department of Health & Environment (KDHE), Kansas Department of Wildlife, Parks and Tourism (KDWPT), the Kansas Department of Agriculture (KDA), and Kansas Water Office (KWO), as well as the federal Army Corps of Engineers (USACE) all have involvement in wetland protection and regulation. Kansas statutes (K.S.A. 82a-325 *et seq.*) require a total of eight state agencies, including KDHE, to review proposed water development projects for "beneficial and adverse environmental effects."

Persons desiring to alter regulatory wetlands in Kansas must file for Section 404 "dredge and fill" permits with the USACE. Simultaneously, such permit requests come to KDHE for a Section 401 water quality certification. The department makes a determination of the projected impact on water quality resulting from the proposed action and may approve the action, approve it with modifications, or deny the action based on these projected water quality impacts.

One activity within KDHE has been the description of what are generally referred to as "reference" conditions for lakes and wetlands in Kansas. In essence, reference water quality conditions for lakes and wetlands occur in watersheds with limited levels of human activity and anthropogenic pollution loads. These "least impacted or better" waterbodies then describe the condition that would be generally attainable if polluting activities were reduced, well buffered, or otherwise mitigated in the general population of lakes and wetlands. Thus, reference condition provides a valuable and attainable water quality goal for a given class of waterbodies.

Based on the water quality and trophic state data collected since the 1970s for lakes and wetlands in Kansas, the following general conclusions regarding reference conditions have been reached. Lakes in Kansas with minimal pollution loads can be expected to achieve mesotrophic-to-slightly eutrophic conditions, with low total nutrient concentrations and relatively high water clarity (Dodds, Carney and Angelo 2006) (Carney 2009) Wetlands with similar minimal pollutant loads could be expected to achieve a trophic state in the low-to-mid range of eutrophic (chlorophyll-a at or under 12-to-18 µg/L), with moderate total nutrient levels (total phosphorus at or under 50-to-80 µg/L) (KDHE 2002). For this 305(b) cycle, 6 wetlands achieved "least impacted or better" status for nutrient levels and trophic state condition, however all were small and totaled less than 1% of the wetland acres assessed. As stated earlier in this report section, over 90% of wetland acres exceed this least impacted or better threshold by a sizeable margin, suggesting public wetlands in Kansas are at high risk from nutrient pollution and eutrophication.

III. 303(D) ASSESSMENT RESULTS

The Kansas 2018 303(d) list identifies 498 station/pollutant combinations of water quality impairment on lakes, wetlands and stream systems (watersheds), encompassing 2,437 stream segments, and in need of TMDLs to address the offending pollutants. The 2018 list identifies 480 station/pollutant combinations of waters that were previously listed as impaired but are now meeting water quality standards, with 19 of these being new in 2018. The complete list is included in the printed version of the integrated report submitted to USEPA (**Appendix B**). This list also can be accessed by the public via the internet at http://www.kdheks.gov/tmdl/methodology.htm.

Public Health Issues

Kansas is one of only half a dozen states in the nation to house both Health and Environment functions within a single organization. As such, the KDHE strives to integrate functions to best serve the environmental health of its citizens. In ambient water monitoring, three environmental areas stand out as potential public health concerns, and as such receive special attention: Drinking water use, Beach and water recreation use, and Fish Consumption. In addition, the agency has several rapid response programs and a tracking system to respond to public concerns.

I. DRINKING WATER USE

Use of surface waters in Kansas for drinking water supply (both public and domestic) is first determined through Use Attainability Analyses (UAAs). The domestic water supply use can be either existing or attainable; therefore, the UAA process examines the likely hydrology and ambient water quality to determine attainability. Existing drinking water supply use can be verified by inspection of water rights from the Division of Water Resources of the Kansas Department of Agriculture. Attainable use is assigned to perennial streams that exhibit parameter concentrations (chloride, sulfate, fluoride, total dissolved solids) that are less than twice applicable criteria or guidance. As a result of this screening, most streams in the central and eastern portions of Kansas could potentially support drinking water uses. Similarly, lakes are assessed and, more often than not, found to support attainable drinking water supply uses.

Currently, 21,705 stream miles (72% of the Kansas Surface Water Register) and 188,924 acres of lakes bear the designated use for Domestic Water Supply. Of the lake acreage, 149,839 acres currently serve as existing and emergency public water supply, but no such calculation can be made easily for stream mileage. Moreover, assessment of support for this use is complicated by the provisions of the Kansas Surface Water Quality Standards. Application of water quality criteria protective of drinking water is to occur at "the point of domestic water supply diversion." Therefore, true assessment is focused on support of existing uses. Furthermore, domestic water supply use is defined as the production of potable water after appropriate treatment. The ambient water quality should not confound the routine treatment of the raw water supply into potable water for human consumption. However, assessment of drinking water use support under 303(d) is chiefly directed at the potential, attainable use of that water at some unspecified future time.

Assessing support of the water quality criteria underlying the drinking water use involves evaluating monitoring data for too-frequent excursions from applicable numeric criteria, such as nitrate, sulfate, chloride, arsenic or fluoride. In cases of elevated nitrate, the root cause has typically been wastewater with insufficient denitrification. Such situations call for the water to be classed Category 5 with a TMDL scheduled for development.

Impairments due to chloride, sulfate, arsenic and fluoride are often contributed by natural, geologic sources, sometimes exacerbated by water use and reuse, concentrating salts through water loss induced by evapotranspiration. To the degree possible, background concentrations are established as part of the water quality standards that reflect natural contributions that exceed the existing criteria for those pollutants, are not influenced by flow alterations or diversions, and leave the surface water usable under the definition of domestic water supply use.

Impairment from excessive nutrients is assessed relative to trophic conditions in lakes that present problems to aquatic life, recreation, and drinking water. Endpoints used by eutrophication TMDLs are set at level that should assure full attainment of all three of these designated uses. Similarly, screening for excess phosphorus in streams result in adaptive TMDLs that continue to reduce loadings of phosphorus from point and non-point sources until such time that blue-green algae counts and complaints of taste and odor in drinking water are minimized.

II. BEACH USE (HARMFUL ALGAL BLOOMS AND ALGAL TOXINS)

Background

Eutrophication, the enrichment of waterbodies with excess nutrients and the nuisance algal growth that results, causes many impacts to water quality and to the beneficial uses we expect our lakes and streams to provide us. Impacts can range from disrupting ecological system integrity, to reducing revenues from recreational use, to increasing costs and risks related to providing drinking water (Dodds, Bouska, et al. 2009). Perhaps the most noticeable impact to the general public is the generation of large population explosions of phytoplankton that are generally called "blooms." These algae blooms are the net result of over-enrichment of lakes with plant nutrients (primarily phosphorus, but also nitrogen). Blooms can occur suddenly, and at all times of the year, and can be composed of numerous species from various taxonomic groups. However, the most common blooms, and certainly of the most concern to public health, are blooms composed of blue-green algae (cyanophytes).

Blue-green algae are actually large, free-living, photosynthetic bacteria. They are a natural part of the ecology, usually occurring in fairly small numbers, only becoming a problem when they grow to extreme populations. They are lumped under the functional term "algae" with other organisms because they share many of the same habitat requirements as these other types of algae (green algae, diatoms, euglenoids, dinoflagellates, *etc.*). A blue-green algae bloom can be extremely large, numbering in the millions of cells per milliliter of water. Such blooms create conditions that are visually objectionable to the public, produce foul odors, obstruct boats and other forms of recreation, cause taste and odor problems in finished drinking water, and cause fishkills. Most blue-green algae blooms will occur in nutrient enriched lakes during the summer, when water temperatures are highest, but a few species prefer cooler temperatures. Although they produce sufficient aesthetic problems to impair many recreational and economic activities, their ability to produce toxic compounds makes them a threat to public health as well.

Blue-green algae are capable of producing a number of different biochemical compounds that are toxic to warm blooded organisms (for the most part). These compounds fall into three general categories: hepatotoxins (which primarily affect the liver and other internal organs), neurotoxins (which primarily impact the nervous system), and dermatotoxins (which affect the skin, mucus membranes, eyes, ears, and throat). Over 200 different algal toxins have been identified in freshwaters (where blue-green algae are the most common toxic species) and in marine environments (where dinoflagellates tend to be the most common type of toxic algae). In the Midwest, microcystins (a type of hepatotoxin) are the most commonly documented algal toxin type (Graham, et al. 2010), although other toxins (such as the neurotoxic anatoxin-a and saxitoxin) do occur at a lesser frequency. There are almost 100 identified variants of the microcystin toxin known. Some of these algal toxins rival, or exceed, the potency of cobra venom.

Over two dozen genera of blue-green algae may be found in the waters of Kansas, but the majority of blooms and complaints are attributable to five genera. All are colonial forms, forming filaments or large globs of cells that look like green cottage cheese floating in the water. These include *Microcystis* spp. (species can produce the hepatotoxin microcystin), *Anabaena* spp. (species can produce both hepatotoxins and neurotoxins), *Aphanizomenon spp.* (species can produce neurotoxins), *Planktothrix* spp. (species can produce both neurotoxins and the hepatotoxin microcystin), and *Cylindrospermopsis raciborskii* (can produce the hepatotoxin cylindrospermopsin). Essentially all species of blue-green algae produce dermatotoxins that are associated with their cell walls. Most blue-green algae have optimal growth at higher ambient temperatures (>27^{o} C), but some species, such as *Planktothrix rubescens* seem to grow quite well in the middle of winter, often forming reddish masses of algae under ice layers.

Around the world, pets, livestock, wildlife, and people have become ill or died after exposure to blue-green blooms and their toxins, including Kansas. Exposure to algal toxins is primarily through the ingestion of water containing blue-green algae, but exposure can also occur through breathing aerosols or through skin contact. Because of the increase in lakes and streams suffering from nutrient enrichment and eutrophication, problems related to blue-green algae and their blooms have also increased dramatically over the last few decades. Many U.S. states, and a number of foreign countries, have adopted formal programs and protocols for dealing with the public health threat posed by excessive blue-green algae in our waters. Kansas joined those other entities several years ago by adopting a formal response policy on August 13, 2010.

Harmful Algal Bloom Response Program

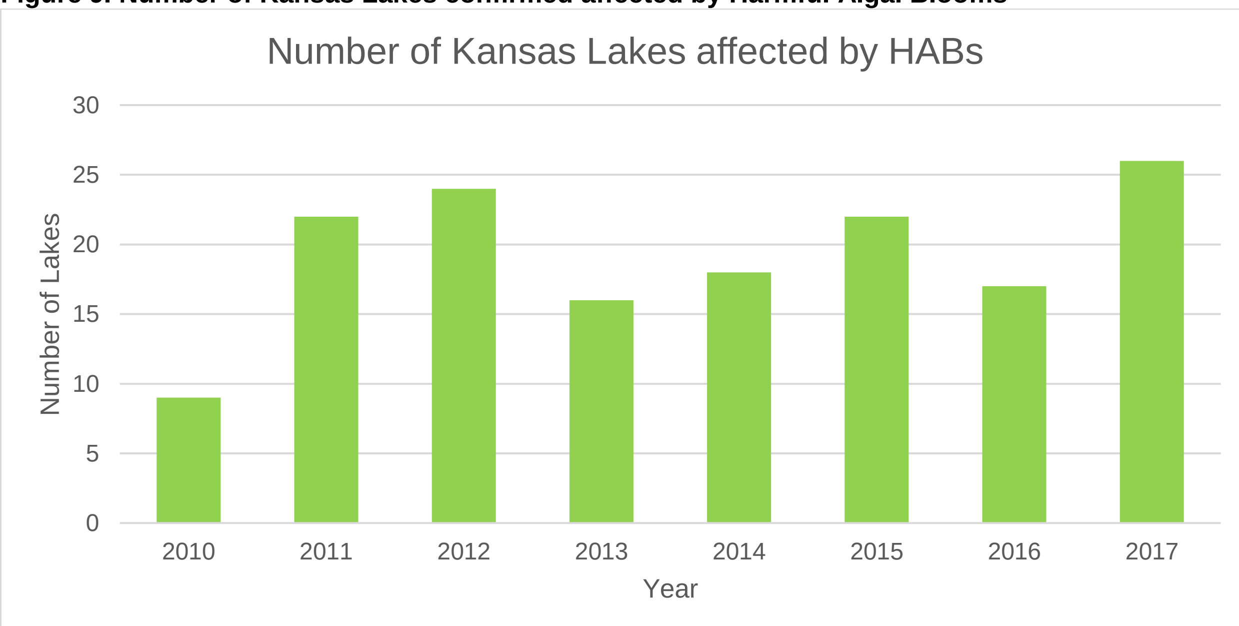
The program adopted by the Kansas Department of Health and Environment is a joint effort among several Bureaus within both Divisions (Health and Environment) of the agency. It is complaint driven, with citizens, lake managers, or other officials able to access and submit a form through the Harmful Algal Bloom response program at www.kdheks.gov/algae-illness. Once received, the complaint is vetted, and appropriate sampling of the waterbody is conducted. Sampling is directed towards the major points of public access onto the water (marinas, swimming beaches, main boat ramps or dock facilities, *etc.*), and continues until algal cell counts and toxin levels decline to safe thresholds. The program is limited to publicly owned or managed waterbodies. The primary purposes of the program are to inform the public of health risks associated with the current condition of the lake, to advise lake managers as to what course of action is most appropriate, and supply technical expertise to those lake managers.

Three levels of threat are recognized under the program:

- "Public Health Watch," where hazardous conditions are possible or present;
    - ≥80,000 to <250,000 blue-green cells/ml OR
    - microcystin concentrations of ≥4 to <20 µg/L
- "Public Health Warning," where conditions are believed to represent a threat to health and safety
    - ≥250,000 to ≤10,000,000 blue-green cells/ml OR
    - microcystin concentrations ≥20 µg/l to 2,000 µg/L
- "Recommended Lake Closure," where it is recommended that all in-lake recreation cease and that picnic, camping, and other public land activities adjacent to affected waters be closed (Chorus and Bartram 1999)
    - >10,000,000 blue-green cells/ml OR
    - microcystin concentrations of >2,000 µg/L

The Harmful Algal Bloom response program is a collaborative effort between the Division of Health and Division of Environment. The program can be reached by telephone (785-296-1664) or through a web reporting interface (http://www.kdheks.gov/algae-illness/index.htm). Through the web interface, private citizens, organizations or agencies, or medical and veterinary professionals can complete and submit an Algae Bloom Report Form, a Human Algae Illness Reporting Form, or an Animal Illness reporting Form. Reports to the BGA program are channeled to the appropriate entities at KDHE, which may include surface water monitoring, drinking water, and epidemiology, and credible reports are followed up with monitoring as needed. Lakes that have confirmed BGA blooms of a given magnitude are placed on Advisory or Warning status and subject to routine high frequency monitoring; lake status is posted on the same website and updated at least weekly.

Figure 9. Number of Kansas Lakes confirmed affected by Harmful Algal Blooms



As seen in **Figure 9**, Kansas has consistently seen 15-20 lakes affected by HABs each season, which coincides with the recreational season from April 1st through October 31st for Kansas Lakes. The HAB events tend to increase as summer temperatures increase. Some events are short in duration, but more recent HAB events are commonly larger blooms that tend to persist for the majority of the time from late June through late August. This current HAB year (2017) has the greatest number of lakes affected by HABs on record at 26. Figure 2 details the number of samples collected and analyzed (for toxin or algal cell counts) by the KDHE HAB program. The number of samples for each lake are determined by the HAB program on a site specific basis determined by the size of the lake and public access, which are often associated with the locations of swimming beaches, boat ramps and fishing docks.

III. FISH CONSUMPTION

Public health concerns related to the consumption of locally caught fish are addressed in the

2018 fish advisories. These advisories are available on the KDHE website at http://www.kdheks.gov/befs/download/Kansas_issues_revised_fish_consumption_advisories_Jan_2018.pdf and are also printed in the 2018 Fishing Atlas (KDWPT 2018).

For many years, KDHE has designated waterbody-specific advisories and warnings. However, in 2013, for the first time, KDHE also issued a statewide advisory due to the presence of mercury in fish tissue. Restrictions are based on consumer type (sensitive population *vs.* general public) as well as fish species. Harmful algae blooms are also mentioned in the advisory as they relate to fish consumption.

IV. Other Considerations

In addition to routine and proactive surface water monitoring, KDHE also provides immediate response to events that may affect or reflect surface water quality, ground water quality, or public health. The agency also places a priority on quick response to citizen and business concerns. One of these programs is the Harmful Algal Blooms program, which has already been discussed. Others include the Spills program and Fishkill program.

Spills Program

One rapid response program is the Spills Program, administered by the Bureau of Environmental Remediation and operated in conjunction with the Kansas Corporation Commission (KCC), for spills on oil leases. Private citizens, businesses, and organizations can use the Kansas Spill hotline to report spills, discharges and emergency releases. The program can be reached by telephone (785-291-3333) or email (Kdhe.SpillHotline@ks.gov), 24/7.

The Spills Program is authorized by Kansas law (KSA 65-171d and KAR 28-48) and is used to address events that can be quickly resolved with the goal of preventing long term harm to our soil or water resources. If a spill or release impacts groundwater, it may be referred to a remedial program to address the problem, but sometimes the spiller is successful in isolating groundwater impacts and can remediate it immediately through the Spills Program.

Table 28 presents a brief summary of events investigated and resolved by the Spills Program in 2016-2017. This count does not include spills that occurred in contained, non-flowing waterways (such as dry road ditches or dry storm sewers) and were cleaned up before flowing water or stormwater was introduced into the system. Also, it does not include events overseen or investigated by KCC, which would include any spill related to petroleum extraction (hydrocarbons, drilling fluids, brine, *etc.*) before it is sold by the producer.

Table 28. Summary of 2016-2017 spill events

Category	2016	2017
KDHE purview: surface water impacted	23	48
with fishkill events	*(0)*	*(0)*
KDHE purview: Groundwater impacted	7	4
with referral to long-term remediation	*(0)*	*(1)*

Fishkill Program

Another rapid response program is the Fishkill Response program, administered through the Bureau of Environmental Field Services and coordinated with colleagues from KDWPT. In 2016-2017, KDHE responded to 8 fishkill events. These were investigated and resolved, and a brief summary is presented in **Table 29.** None of the fishkills were associated with Hazmat spills noted in **Table 28,** but four fishkills were associated with accidental discharge events that were reported and cleaned up through different reporting channels.

Table 29. Summary of fishkill events investigated by KDHE 2016-2017

Waterbody Type	Cause	Year		Grand Total
		2016	2017	
Lake or Pond	Natural kill, winter kill, summer kill, algal toxins, algal oxygen depletion	1	4	5
	Temperature extremes	0	0	0
	Toxics, chlorine, surfactants, organic compounds	0	0	0
	Unknown	0	0	0
	TOTAL	**1**	**4**	**5**
Spillway	Flow related event	0	1	1
	TOTAL	**0**	**1**	**1**
River, Stream, or Creek	Natural	0	0	0
	Toxics, chlorine, surfactants, organic compounds	0	1*	1
	Unknown	0	1	1
	TOTAL	**1**	**2**	**2**
GRAND TOTALS		**1**	**7**	**8**

*This was associated with an oil spill. Spills related to mineral extraction are not handled through the KDHE BER Spills Program, but rather through the Kansas Corporation Commission.

Environmental Complaint Tracking System

In 2017, the Kansas Department of Health and Environment Information Technology (IT) department developed a new Environmental Complaint Tracking System (ECTS). In the past, the agency used several different internal systems within each Bureau to track and resolve environmental complaints. The new ECTS is a single unified system, used across the Division of Environment, linking the Bureau of Air, Bureau of Water, Bureau of Waste Management, Bureau of Remediation, and the Bureau of Environmental Field Services, which oversees the six district offices located throughout Kansas.   This new system will increases communications across the Division of Environment and supports seamless compliant resolution. Complaint information and details can now be easily shared between staff on an internal platform improving data access and exchange.   Program supervisors and managers can also use the system to query compliant data to better manage staff workload and resources, ensuring high quality customer service to the public.

PART D. GROUNDWATER MONITORING AND ASSESSMENT

Overview

Kansas no longer maintains a statewide groundwater quality monitoring program, and funding for its renewal appears unlikely in the near future. However, an earlier monitoring program (suspended in 2002 owing to budgetary constraints) routinely evaluated groundwater quality at more than 200 sites. Individual wells in the monitoring network were sampled on a two-year rotational basis, with approximately half the wells being sampled in any given year. All wells in the network adhered to specific siting, depth, and construction criteria, and the network as a whole was deemed representative of the state's major aquifer systems. The program's surviving electronic database contains roughly 150,000 records spanning 120 different physical, chemical, and radiological parameters and 327 groundwater quality monitoring locations. Additional background information is presented in the program's Quality Assurance Project Plan and accompanying set of Standard Operating Procedures, last revised in 2000 **(KDHE 2000)**,

Groundwater Monitoring by Other Agencies

The Kansas Geological Survey, with funding from the Kansas Water Office, maintains the state's Master Ground-Water Well Inventory, which links together its own databases with those from KDHE and Kansas Department of Agriculture's Division of Water Resources (http://www.kgs.ku.edu/HighPlains/data/). Most of the information in these databases relates to well logs and water levels, rather than water quality.

In addition to some monitoring done by KDHE, other agencies and entities perform groundwater quality monitoring, typically as part of focused projects on specific issues. Groundwater Management Districts, the Kansas Geological Survey, and the U.S. Geological Survey (USGS) test groundwater for various management and research purposes and have done so for many years. One example is a series of cooperative projects done by Kansas Geological Survey, US Bureau of Reclamation, Groundwater Management District 2, and the Kansas Water Office to look at salt intrusion into the Equus Beds of the High Plains Aquifer; information is available at http://www.kgs.ku.edu/Hydro/Equus/index.html, and some results are available as Kansas Geological Survey reports (Young, et al. 2001).

The High Plains Aquifer is the primary water source for the western half of the state; the Equus Beds represents an area of relatively higher potential recharge, where interaction with surface water and alluvial aquifers occurs. The USGS continues to monitor activities related to the Equus Beds and is conducting some additional groundwater monitoring (Teresa Rasmussen, USGS, pers. comm. January 2015); a summary follows.

The USGS collected groundwater samples during 2011-15 as part of the *Equus* Beds groundwater project. The purpose of the *Equus* project is to define water quantity and quality conditions related to artificial recharge of the *Equus* Beds aquifer, to describe the chemical and hydrologic processes affecting the aquifer, and to evaluate the effects of aquifer storage and recovery on water quantity and quality. Since 1995, more than 10,000 surface water and groundwater water-quality samples have been collected and analyzed for more than 400 compounds, including most of the compounds on the USEPA's primary drinking-water standards maximum contaminant level list and secondary drinking-water regulations secondary maximum contaminant level list. Samples were analyzed for major ions, trace elements, nutrients, bacteria, pesticides, volatile organic compounds, dissolved radionuclides, coliphage, arsenic species, and glyphosate. Water-quality constituents of concern for the *Equus* project include specific conductance, oxidation-reduction potential, chloride, sulfate, manganese, nitrate, iron, arsenic, and total coliform bacteria. An overview of the project, with links to reports and data tables, is available at http://ks.water.usgs.gov/equus-water-quality, and published reports are also available (Tappa, et al. 2015).

As part of the National Water Quality Assessment Program (NAWQA) groundwater program, the USGS also collected groundwater samples from 29 wells in northeast Kansas in 2011, one well in northeast Kansas in 2013, and ten wells in western and central Kansas in 2015. Samples were analyzed for trace elements, nutrients, organics, microbiological indicators, emerging contaminants, and age tracers. Data from the sites will be used as part of NAWQA's principal aquifer studies to assess trends in groundwater quality and suitability as a source of drinking water. Data can be downloaded from http://waterdata.usgs.gov/nwis.

Groundwater Monitoring by KDHE

Some groundwater quality information continues to be gathered by KDHE through the efforts of its major regulatory bureaus; see Error! Reference source not found. for an overview of state groundwater protection and monitoring programs. The Bureau of Environmental Remediation routinely samples groundwater from the vicinity of groundwater remedial sites, storage tank cleanup sites, and a few active surface mining operations. The Bureau of Waste Management obtains groundwater quality information from 69 active and 129 closed landfills as well as hazardous waste sites across the state. BOW requires a number of major NPDES permit holders to periodically submit data on groundwater quality. Examples include large CAFOs, meat processing facilities, electrical power plants, and a few municipal WWTFs. Underground Hydrocarbon Storage well and brine storage pond permits as well as Underground Injection Control Class III salt solution mining well regulations also require submittal of data on groundwater quality. The Underground Storage Well and brine storage pond regulations and the Underground Injection Control regulations require monitoring the shallow groundwater for brine and product releases to help ensure operations are conducted in a protective manner.

Monitoring activities generally focus on surficial groundwater and/or a very limited set of analytical parameters; see **Table 31** for a summary of major sources of groundwater contamination in Kansas. The most important and ubiquitous contaminant found in groundwater is nitrate, because it affects usability of water as a drinking water source. Nitrates are primarily from anthropogenic sources: fertilizer storage and application as well as human and livestock waste. Agricultural and industrial chemicals and refined hydrocarbons found in groundwater (such as atrazine, carbon tetrachloride, and gasoline) are also of human origin. However, other groundwater contamination is the result of leaching or concentration of naturally occurring soil chemicals (such as chloride, fluoride, arsenic, selenium, and radionuclides); human activities may facilitate the leaching or concentration of substances, but the contamination is indirect.

A statewide cumulative summary of groundwater contamination is provided in **Table 32**. These assorted monitoring operations are not intended to provide representative information on the state's major aquifer systems or to serve as a coordinated and comprehensive ambient groundwater quality monitoring program, but rather a tracking system for known contamination issues. For Underground Injection and Hydrocarbon and brine wells, a site is considered "resolved" once all appropriate cleanup actions are underway, even if the process may require a number of years for complete cleanup. Groundwater monitoring at CAFOs is used to detect if the waste management system is protecting groundwater from nutrient releases rather than an implied discharge. Some swine facilities are required by Kansas Statutes to install groundwater monitoring based upon number of animal units confined and the depth to groundwater. The secretary may require installation and sampling of groundwater monitoring wells in the vicinity of any waste retention lagoon or pond when the Secretary determines necessary.

Groundwater monitoring related to PWSSs is addressed separately in the next section, because of its direct impact on human health. Under the Safe Drinking Water Act, public water suppliers are required to submit data on source water quality. In Kansas, a majority of sources are groundwater.

Table 30. Summary of state groundwater protection programs

Programs or Activities	Check (X)	Implementation Status	Responsible Agency / Bureau
Monitoring, mapping, and characterization			
Ambient groundwater quality monitoring		(Suspended in 2002)	(KDHE)
Aquifer mapping	X	Established	KGS
Aquifer characterization	X	Ongoing	KGS
Aquifer vulnerability assessment	X	Ongoing	KDHE-BOW
Comprehensive data management	X	Ongoing	KGS, KDHE-BOW, -BER, -BWM
Protection and planning			
Interagency coordination for groundwater protection initiatives	X	Ongoing	KWO
Best Management Practices (nonpoint)	X	Established	KDHE, KWO
Groundwater classification – for CAFO design	X	Established	KDHE-BOW
Pollution Prevention Program (for small businesses)	X	Established	KDHE-BER
Source Water Assessment Program (SWAP)	X	Established	KDHE-BOW
Drinking Water Protection Program (DWPP)	X	Ongoing	KDHE-BOW
Vulnerability assessment for drinking water	X	Ongoing	KDHE-BOW
State septic system regulations	X	Established	KDHE-BOW
Underground Storage Tank (UST) installation requirements (designed to prevent release of petroleum and hazardous materials)	X	Established	KDHE-BER
Permitting			
Industrial and Municipal discharge permits	X	Established	KDHE-BOW
CAFO-specific Groundwater protection regulations	X	Established	KDHE-BOW
Livestock Waste Management Program to prevent surface water and groundwater pollution	X	Established	KDHE-BOW
Water quality standards for groundwater recharge use	X	Established	KDHE-BOW
Pesticide State Management Plan	X	Established	KDA
Underground Storage Tank (UST) Permit Program (permits issued to ensure compliance with operating regulations)	X	Established	KDHE-BOW
Underground Hydrocarbon Storage Well Program (for pressurized HCs in salt caverns and associated brine storage ponds)	X	Established	KDHE-BOW
Underground Injection Control Program (for Class I deep disposal injection wells, Class III salt solution mining wells, and Class V shallow injection wells)	X	Established	KDHE-BOW
Underground Injection Control Program (for Class II injection wells)	X	Established	KCC
Well installation regulations for water wells, Class I, III, and V injection wells, and underground HC storage wells)	X	Established	KDHE-BOW
Well installation regulations (for Class II injection wells)	X	Established	KCC

Table 30, cont'd.

Programs or Activities	Check (X)	Implemen-tation Status	Responsible Agency / Bureau
Remediation			
Active Superfund Amendments and Reauthorization Act (SARA) Title III program	X	Established	KDHE - BER
Resource Conservation and Recovery Act (RCRA) Primacy	X	Established	KDHE – BWM
State Cooperative Program (State-led equivalent to Federal Superfund)	X	Established	KDHE-BER
State Water Plan Orphan Sites (Response to contamination where no viable responsible party has been identified)	X	Established	KDHE - BER
UST Remediation Fund (provides financial assurance for cost of remediating releases of petroleum)	X	Established	KDHE - BER
Well abandonment regulations (for both water and mineral wells)	X	Established	KDHE & KCC

KGS = Kansas Geological Survey
KDA =Kansas Department of Agriculture
KCC = Kansas Corporation Commission
KWO = Kansas Water Office
KDHE-BOW = Kansas Department of Health and Environment Bureau of Water
KDHE-BER = KDHE Bureau of Environmental Remediation
KDHE-BWM = KDHE Bureau of Waste Management

Table 31. Major sources of groundwater contamination for Kansas

Highest Priority Contaminant Sources	Factors Considered in Selecting a Contaminant Source	Types of Contaminants
Agricultural Activities:		
Chemical and grain facilities	A, C, D	2, 3, 4, 5
Animal feedlots	A, C, D, E	5, 7, 10
Irrigation practices	A, C, E, F, H	6, 7, 8, 9
Land application of pesticides, fertilizer and manure	A, C, E	1, 2, 5,10,12
Storage and Treatment Activities:		
Land application (regulated/permitted)	A, C, D, E	5, 7, 10
Storage tanks (AST/LUST)	A, B,C, D	4
Surface impoundments	A, E	5, 8
Disposal Activities:		
Landfills and illegal dumping	A, C,E	3, 4, 7, 8
Deep injection wells	A, G	4, 7, 8, 13
Other Activities:		
Active/abandoned industrial facilities (including dry cleaning)	A, B, C	2, 3, 4, 5, 7, 8, 9, 13
Oil and gas activities (including extraction and refineries)	A, B, C, D	4, 7, 8, 9
Pipelines and sewer lines	A, E	3, 4, 5
Salt water intrusion	B, C, D, E	7
Spills, trucking, rail	A, D	2, 3, 4, 5, 7, 8

Factors Considered in Selecting a Contaminant Source:
(A) Human health and/or environmental risk (toxicity)
(B) Size of population at risk
(C) Location of sources relative to drinking water sources
(D) Number and/or size of contaminant sources
(E) Hydrogeologic sensitivity
(F) State findings, other findings
(G) Documented from mandatory reporting
(H) Geographic distribution/occurrence
(I) Other criteria as described in narrative

Types of Contaminants:
(1) Inorganic pesticides
(2) Organic pesticides
(3) Halogenated solvents
(4) Petroleum compounds
(5) Nitrate
(6) Fluoride
(7) Salinity/brine
(8) Metals
(9) Radionuclides
(10) Bacteria
(11) Protozoa
(12) Viruses
(13) PCBs
(14) Other contaminants as described in narrative

Table 32. Groundwater contamination: statewide cumulative summary through December 31, 2017

Source Type	# of KS Sites	# of Sites with Confirmed	# with Confirmed Groundwater Contamination	Primary Contaminants	# of Site Assessments	# of Sites with Source Removed	# of Sites with Corrective Action Plans	# of Sites with Active Remediation	# of Sites with Ongoing Monitoring	# of Sites with Cleanup Resolved
NPL **	12	12	11	VOCs, metals	12	Unavail	0	7	7	0
CERCLIS (non-NPL)**	100	100	19	VOCs, metals , PCBs	199	Unavail	2	3	2	65
DOD/FUDS**	500	500	116	VOCs, metals, refined petroleum	500	Unavail	2	27	11	167
LUST (Leaking Underground Storage Tanks)	11,092	5,273	4,471	gasoline and diesel fuels	11,092	Unavail	N/A	167	1,147	9,777
State Sites (not including LUST sites or KCC jurisdiction sites)	2,179	2,2,50 9	1,110	VOCs, metals, refined petroleum, nitrates	2,509	Unavail	66	205	201	1,211
Concentrated Animal Feeding Operations	6,288	N/A	N/A	Nitrate and chlorides	6,298	Unavail	N/A	N/A	75	N/A
RCRA Corrective Action (incl. 6 military sites)	53	53	53	VOCs, metals, semi-volatiles	46	11	23	23	39	15
Solid Waste Landfills-Active +	69	40	40	VOCs & metals	68	N/A	1	1	69	0
Solid Waste Landfills – Closed +	129	94	94	VOCs & metals	109	N/A	4	4	100	0
Underground Injection Wells ++	32	4	3	Brine	4	4	2	2	4	4
Underground Hydrocarbon Storage Wells	10	1	0	Brine	1	1	1	1	1	1
Underground Hydrocarbon Storage Brine-Storage Ponds (Multiple ponds per site)	9	9	9	Brine	9	9	9	9	9	9

+ KDHE Bureau of Waste Management requires groundwater monitor at all active landfills and for a minimum 30 years at all closed landfills,
++ Represents Class I and III injection wells, but does not include Class II brine injection wells.
N/A - not applicable; CERCLIS - Comprehensive Environmental Response, Compensation, and Liability Information System; Includes non-NPL Management Assistance (CERCLA Lead and Superfund sites); DOD/FUDS - Department of Defense/Formerly Used Defense Sites; LUST - Leaking Underground Storage Tanks; NPL - National Priority List; NPS - Nonpoint Source; RCRA - Resource Conservation and Recovery Act; VOC – volatile organic compounds

Groundwater Monitoring associated with Public Water Supply Systems

A Public Water Supply System (PWSS) entity may be composed of multiple facilities or components: groundwater wells, surface intakes, consecutive connections, treatment plants, storage tanks, and distribution systems. Normally, water flows from a raw source (or consecutive connection, if purchased from another entity) into a treatment plant, and then into the distribution system. Treated water can also be purchased through a consecutive connection from another PWSS which would flow directly into the distribution system with no further treatment. Public water supply compliance monitoring is usually performed at the end of the treatment plant processes just prior to entry into the distribution system, or in the distribution system itself. Treated water samples do not necessarily reflect the unaltered state of the raw water that initially flows into the treatment plant.

Only a few compliance samples are collected at the raw water source, *i.e.*, groundwater wells and surface intakes. However, some raw water monitoring is performed under the aegis of Public Water Supply, and the results are reported here. Raw water sampling (whether from a groundwater or surface water source) is normally limited to just a few types of sampling:

1. (Compliance Monitoring) Total organic carbon samples are collected from intakes to be used as part of the Disinfection By-Product rule determinations. The samples are matched up with a corresponding treatment plant sample so compliance can be determined.
2. (Compliance Monitoring) Groundwater samples are collected as part of the Groundwater Rule, which requires source monitoring after a positive microbiological sample is collected in the distribution system. The goal is to determine whether a positive in the distribution system can be traced back to raw source water. In Kansas, since the inception of the GWR, few positive samples have been collected at a well after a distribution system positive sample.
3. (Not for Compliance Monitoring) When an application is made for installation of a new public water supply well, plans are submitted, inspections are performed, and water quality test well kits are taken to provide baseline testing on a broad spectrum of inorganic, organic, radiological, and microbiological parameters. As a service to Public Water Supply Systems, KDHE offers special study sampling and test well kit monitoring to help identify the best sources of water. Test wells are drilled and water quality is determined before permits are issued. These samples are not used for compliance determinations, but are considered special study samples specifically for the permitting process.
4. (Not for Compliance Monitoring) Special study samples are performed intermittently by systems for many different reasons. Normally these samples help systems identify or correct a problem of which they may or may not be aware. Often special studies are completed as part of an engineering firm’s work when they are hired by the PWSS to make improvements or perform maintenance.

Drinking water facilities are tested on a three-year rotating cycle, so every facility in the state should be represented once in any consecutive three year window. **Table 33** presents results of 2014-2016 groundwater testing from both routine compliance monitoring samples and special study sampling (not related to compliance monitoring) completed at water treatment plants and groundwater wells.

Treated groundwater source samples are from wells used to supply drinking water. Untreated groundwater source samples may be from wells used to supply drinking water, or may be locations where groundwater was tested for future possible use for drinking water supply. Note that Maximum Contaminant Levels (MCLs) do not apply to untreated drinking water, as treatment removes most contaminants, but counts of MCL exceedences are given as reference points.

Fluoride enters groundwater from natural deposits and by water additives via drinking water treatment known as fluoridation. Water systems that fluoridate their water are required to monitor their treated water more frequently than systems that have do not fluoridate their drinking water and have negligible or low levels of naturally occurring fluoride in their drinking water source.

The data provided here are presented only as an auxiliary to groundwater monitoring. Complete reporting on drinking water monitoring and compliance can be found on the KDHE Water Supply Section website at:
http://www.kdheks.gov/pws/monitoringcompliance/annualcompliancereports.html

Table 33. Results of groundwater monitoring associated with Public Water Supply Systems, 2014-2016

Monitoring Data Type	Parameter / Group	Sources	Total Samples	Samples with No Detects	Samples with Detects	Detects Nitrate ≤ 5 mg/L	Detects Nitrate >5 and ≤ 10 mg/L	Detect Sample Exceeding MCL*	Compliance Violations **
Untreated Water	VOC	83	5903	5841	62	--	--	3	--
	SOC	81	1459	1407	52	--	--	0	--
	EDB	58	197	197	0	--	--	0	--
	Arsenic	17	75	18	57	--	--	7	--
	Fluoride	16	69	11	0	--	--	0	--
	Mercury	15	69	69	0	--	--	0	--
	Nitrate	16	75	11	64	29	10	25	--
	Selenium	15	71	18	53	--	--	0	--
	E. coli	587	1339	1293	46	--	--	N/A	--
Finished Drinking Water	VOC	801	18818	18754	64	--	--	2	N/A
	SOC	801	989	815	174	--	--	4	0
	EDB	802	895	894	0	--	--	0	0
	Arsenic	815	976	191	785	--	--	49	40
	Fluoride	812	1259	118	1141	--	--	1	0
	Mercury	811	834	834	0	--	--	0	0
	Nitrate	923	3860	303	3557	2302	1083	172	149
	Selenium	811	864	113	751	--	--	16	9

This shows all detected parameters, whether they were measured for compliance or other purposes. Only the "Violations" column applies to MCL exceedances due to actual compliance monitoring results. Special studies or test well kit samples are never used to determine compliance or violations. Many untreated waters are tested but never developed into drinking water sources. Maximum Contaminant Level (MCL) for nitrate is 10 mg/L. EDB = ethyl dibromide. VOC = volatile organic compounds; SOC = synthetic organic compounds. *note that MCLs only apply to finished drinking water, but they are provided for untreated sources as a point of reference. ** Compliance Violations can actually be greater than Number of Exceedances for most analytes, because a single large exceedance can result in up to four compliance violations, due to the four-quarter averaging rule (which applies to all analytes except nitrate).

PART E. PUBLIC PARTICIPATION

As required by federal regulation and the Kansas continuing planning process, the 2018 303(d) list and associated methodology were subjected to public review. Formal public notice of the list was made via the Kansas Register on February 22, 2018. This notice included a link to the KDHE TMDL website, from which interested parties were able to review and download the entire 303(d) list and a detailed description of the listing methodology. KDHE held two public hearings regarding the list, one, in Topeka on March 13, 2018, at KDHE; the other on March 15, 2018, in Salina at the KDHE District Office. No public stakeholders attended the Topeka hearing; one attended the Salina hearing; other attendees included agency staff. The comment period was held open until March 23, 2018. No comments received by the public required any modification of the list.

Based on the proposed 2018 303(d) list, some 17 pollutant-watershed combinations addressing nutrient impairments in the Kansas Lower Republican and Lower Arkansas basins are slated for TMDL development over 2018-2019. These selections may be altered with changing priorities of the State environmental programs or contemporary issues (*e.g.* blue-green algae outbreak) at certain waters within the three basins in the upcoming cycle.

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APPENDICES

Appendix A. Routine and Supplemental Parameters

I. APPENDIX A-1: WATER CHEMISTRY PARAMETERS

Routine and supplemental water chemistry and related parameters analyzed by the Targeted Stream Chemistry Monitoring Program, the Lake and Wetland Program, and the Probabilistic Stream Monitoring Program. R = routine / s = supplemental / . = N/A

TYPE	PARAMETER	Targeted Stream Chemistry Program	Probabilistic Stream Program	Lake and Wetland Program
Inorganic / Composite	Alkalinity, total (as CaCO3)	R	R	R
Inorganic / Composite	Aluminum, total recoverable	R	R	R
Inorganic / Composite	Ammonia, total (as N)	R	R	R
Inorganic / Composite	Antimony, total recoverable	R	R	R
Inorganic / Composite	Arsenic, total recoverable	R	R	R
Inorganic / Composite	Barium, total recoverable	R	R	R
Inorganic / Composite	Beryllium, total recoverable	R	R	R
Inorganic / Composite	Boron, total recoverable	R	R	R
Inorganic / Composite	Bromide	R	R	R
Inorganic / Composite	Cadmium, total recoverable	R	R	R
Inorganic / Composite	Calcium, total recoverable	R	R	R
Inorganic / Composite	Carbon, total inorganic (calculated)	.	.	R
Inorganic / Composite	Carbon, total organic	R	R	R
Inorganic / Composite	Chloride	R	R	R
Inorganic / Composite	Chromium, total recoverable	R	R	R
Inorganic / Composite	Cobalt, total recoverable	R	R	R
Inorganic / Composite	Conductivity (field)	R	.	.
Inorganic / Composite	Copper, total recoverable	R	R	R
Inorganic / Composite	Dissolved oxygen	R	R	R
Inorganic / Composite	Fluoride	R	R	R
Inorganic / Composite	Hardness, total (as CaCO3)	R	R	R
Inorganic / Composite	Iron, total recoverable	R	R	R
Inorganic / Composite	Kjeldahl nitrogen	R	R	R
Inorganic / Composite	Lead, total recoverable	R	R	R
Inorganic / Composite	Magnesium, total recoverable	R	R	R
Inorganic / Composite	Manganese, total recoverable	R	R	R
Inorganic / Composite	Mercury, total	R	R	R
Inorganic / Composite	Molybdenum, total recoverable	R	R	R

TYPE	PARAMETER	Targeted Stream Chemistry Program	Probabilistic Stream Program	Lake and Wetland Program
Inorganic / Composite	Nickel, total recoverable	R	R	R
Inorganic / Composite	Nitrate (as N)	R	R	R
Inorganic / Composite	Nitrite (as N)	R	R	R
Inorganic / Composite	pH (lab)	s	s	s
Inorganic / Composite	pH (field)	R	R	R
Inorganic / Composite	Phosphate, ortho- (as P)	R	R	R
Inorganic / Composite	Phosphorus, total (as P)	R	R	R
Inorganic / Composite	Potassium, total recoverable	R	R	R
Inorganic / Composite	Selenium, total recoverable	R	R	R
Inorganic / Composite	Silica, total recoverable	R	R	R
Inorganic / Composite	Silver, total recoverable	R	R	R
Inorganic / Composite	Sodium, total recoverable	R	R	R
Inorganic / Composite	Specific conductance	R	R	R
Inorganic / Composite	Strontium, total recoverable	R	R	R
Inorganic / Composite	Sulfate	R	R	R
Inorganic / Composite	Temperature water (field)	R	R	R
Inorganic / Composite	Thallium, total recoverable	R	R	R
Inorganic / Composite	Total dissolved solids (calculated)	R	R	R
Inorganic / Composite	Total suspended solids	R	R	R
Inorganic / Composite	Turbidity	R	R	R
Inorganic / Composite	Uranium, total recoverable	R	R	R
Inorganic / Composite	Vanadium, total recoverable	R	R	R
Inorganic / Composite	Zinc, total recoverable	R	R	R
Microbiological	*Escherichia coli (E. coli)*	R	R	R
Organic	Acetochlor	R	R	R
Organic	Alachlor	R	R	R
Organic	Aldrin	R	R	R
Organic	Alpha BHC	R	R	R
Organic	Atrazine (Aatrex)	R	R	R
Organic	beta-BCH	R	R	R
Organic	Bromacil	R	R	R
Organic	Butachlor	R	R	R
Organic	Carbofuran (Furadan)	R	R	R
Organic	Chlordane	R	R	R
Organic	Cyanazine (Bladex)	R	R	R
Organic	DCPA (Dacthal)	R	R	R
Organic	Delta BHC	R	R	R
Organic	Dieldrin	R	R	R

TYPE	PARAMETER	Targeted Stream Chemistry Program	Probabilistic Stream Program	Lake and Wetland Program
Organic	Endosulfan I	R	R	R
Organic	Endosulfan II	R	R	R
Organic	Endosulfan sulfate	R	R	R
Organic	Endrin	R	R	R
Organic	Gamma BHC (Lindane)	R	R	R
Organic	Heptachlor	R	R	R
Organic	Heptachlor epoxide	R	R	R
Organic	Hexachlorobenzene	R	R	R
Organic	Hexachlorocyclopentadiene	R	R	R
Organic	Methoxychlor	R	R	R
Organic	Metolachlor (Dual)	R	R	R
Organic	Metribuzin (Sencor)	R	R	R
Organic	p,p'-DDD	R	R	R
Organic	p,p'-DDE	R	R	R
Organic	p,p'-DDT	R	R	R
Organic	PCB-1016	R	R	R
Organic	PCB-1221	R	R	R
Organic	PCB-1232	R	R	R
Organic	PCB-1242	R	R	R
Organic	PCB-1248	R	R	R
Organic	PCB-1254	R	R	R
Organic	PCB-1260	R	R	R
Organic	Prometon (Pramitol)	R	R	R
Organic	Propachlor (Ramrod)	R	R	R
Organic	Propazine (Milogard)	R	R	R
Organic	Simazine	R	R	R
Organic	Toxaphene	R	R	R
Other	Algal taxonomy (field)	s	R	R
Other	Chlorophyll-a	s	R	R
Other	Macrophyte abundance (field)	.	.	R
Other	Microcystins (by ELISA)	.	.	s
Other	Pheophytin-a	s	s	R
Other	Photosynthetically active radiation (PAR)*	.	.	s
Other	Secchi depth (field)*	.		R
Radiological	Actinium-228	s	.	.
Radiological	Americum-241	s	.	.
Radiological	Antimony-125	s	.	.

TYPE	PARAMETER	Targeted Stream Chemistry Program	Probabilistic Stream Program	Lake and Wetland Program
Radiological	Barium-140	s	.	.
Radiological	Beryllium-7	s	.	.
Radiological	Cerium-141	s	.	.
Radiological	Cerium-144	s	.	.
Radiological	Cesium-134	s	.	.
Radiological	Cesium-136	s	.	.
Radiological	Cesium-137	s	.	.
Radiological	Cobalt-57	s	.	.
Radiological	Cobalt-60	s	.	.
Radiological	Gross alpha	s	.	.
Radiological	Gross beta	s	.	.
Radiological	Indium-111	s	.	.
Radiological	Iodine-123	s	.	.
Radiological	Iodine-131	s	.	.
Radiological	Iodine-132	s	.	.
Radiological	Iodine-133	s	.	.
Radiological	Iron-59	s	.	.
Radiological	Lanthanum-140	s	.	.
Radiological	Manganese-54	s	.	.
Radiological	Molybdenum-99	s	.	.
Radiological	Neodymium-147	s	.	.
Radiological	Neptunium-239	s	.	.
Radiological	Niobium-95	s	.	.
Radiological	Potassium-40	s	.	.
Radiological	Ruthenium-103	s	.	.
Radiological	Ruthenium-106	s	.	.
Radiological	Silver-110m	s	.	.
Radiological	Technetium-99m	s	.	.
Radiological	Thorium-228	s	.	.
Radiological	Tritium	s	.	.
Radiological	Ytterbium-169	s	.	.
Radiological	Zinc-65	s	.	.
Radiological	Zirconium-95	s	.	.

II. APPENDIX A-2: FISH TISSUE PARAMETERS

Routine fish tissue parameters analyzed by the USEPA Region 7 laboratories for the Fish Tissue Contamination Program and Stream Probabilistic Monitoring Programs. R = routine / . = N/A

Type	Parameter	Fillet (through 2013 only)	Whole-fish (through 2013 only)	Fillet and Whole-fish (Current parameters)	Plug (2011 to present)
inorganic	Cadmium	R	R	.	.
inorganic	Lead	R	R	.	.
inorganic	Mercury	R	R	R	R
inorganic	Selenium	R	R	.	.
organic	1,2,4,5 -Tetrachlorobenzene	.	R	.	.
organic	p,p’-DDD	R	R	R	.
organic	p,p’-DDE	R	R	R	.
organic	p,p’-DDT	R	R	R	.
organic	Dieldrin	R	R	R	.
organic	Heptachlor	R	R	.	.
organic	Heptachlor epoxide	R	R	.	.
organic	Hexachlorobenzene	R	R	.	.
organic	gamma-Hexachlorocyclohexane (gamma-BHC)	R	R	.	.
organic	Mirex	.	R	.	.
organic	PCB-1248	R	R	R	.
organic	PCB-1254	R	R	R	.
organic	PCB-1260	R	R	R	.
organic	Pentachloroanisole	R	R	.	.
organic	Pentachlorobenzene	.	R	.	.
organic	Technical Chlordane	R	R	.	.
organic	Oxychlordane	R	.	R	.
organic	cis-Chlordanet	R	.	R	.
organic	trans-chlordane	R	.	R	.
organic	cis-Nonachlor	R	.	R	.
organic	trans-Nonachlor	R	.	R	.
organic	Trifluralin (Treflan)	R	R	.	.

Appendix B. 303(D) LIST

Appendix B contains the most recently completed 2018 303(d) list for the state of Kansas. Current approval status and priority information may be found at http://www.kdheks.gov/tmdl.

Appendix B-1 is a summary of all 303(d) list changes for this assessment cycle.

Appendix B-2 is the public comment version of 303(d) list of waters formerly listed as impaired.

Appendix B-3 is the public comment version of 303(d) list of all waters potentially impaired, including new listings as well as those from previous lists.

I. APPENDIX B-1: SUMMARY OF 2018 CHANGES TO IMPAIRED WATERS LIST

New Category 5 Listings, 303(d) Impaired Waters requiring a TMDL:

Seven new stations listed as impaired for Atrazine. Assessment Method: Chronic Aquatic Life (AQL); more than 10% of samples > 3 µg/L fails the binomial test utilizing samples collected March through October.

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Kansas-Lower Republican	10270104	Kansas River At Kansas City, Kansas	5	Atrazine	SC203
Kansas-Lower Republican	10270102	Soldier Creek Near Topeka	5	Atrazine	SC239
Kansas-Lower Republican	10270104	Kill Creek At Desoto	5	Atrazine	SC253
Lower Arkansas	11030013	Arkansas River Near Arkansas City	5	Atrazine	SC218
Lower Arkansas	11030013	Cowskin Creek At Wichita	5	Atrazine	SC730
Neosho	11070205	Cherry Creek Near Faulkner	5	Atrazine	SC605
Upper Arkansas	11030004	Arkansas River Near Dundee	5	Atrazine	SC584

Nine new stations listed as impaired for Biology. Assessment Method: The Aquatic Life Use Support Index (ALUS) indicates partial or non-support.

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Kansas-Lower Republican	10270103	Delaware River at Hwy 36	5	Biology	SB352
Kansas-Lower Republican	10270104	Wakarusa River Near Eudora	5	Biology	SC500
Kansas-Lower Republican	10250017	Republican River Near Rice	5	Biology	SC510
Lower Arkansas	11030013	Slate Creek Near Wellington	5	Biology	SC528
Marais des Cygnes	10290104	Marmaton River	5	Biology	SB324
Neosho	11070205	Labette Creek Near Labette	5	Biology	SC564
Smoky Hill-Saline	10260007	Big Creek near Russell	5	Biology	SC752
Solomon	10260015	Solomon River At Niles	5	Biology	SC266
Walnut	11030017	Whitewater River At Towanda	5	Biology	SC038

One new station listed as impaired for Dissolved Oxygen. Assessment Method: More than one sample every three years, on average, measures below 5 mg/L.

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Cimarron	11040007	Crooked Creek Near Englewood	5	Dissolved Oxygen	SC600

Four new lake stations listed as impaired for Eutrophication. Assessment Method: (a) If Lake is an active or reserve domestic water supply: average chlorophyll *a* concentration > than the site specific chlorophyll *a* criterion in Table 11 of the Kansas Surface Water Quality Standards or > 10 µg/L. (b) If Lake has a designated use of primary contact recreation but is not an active or reserve public water supply: average chlorophyll *a* concentration > 12 µg/L. (c) If Lake has a designated use of secondary contact recreation but is not an active or reserve public water supply: average chlorophyll *a* concentration > 20 µg/L.

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Kansas-Lower Republican	10270103	Banner Creek Lake	5	Eutrophication	LM032001
Lower Arkansas	11030012	McPherson Wetlands	5	Eutrophication	LM014701
Upper Arkansas	11030006	Hodgeman Co.SFL/W.A.	5	Eutrophication	LM074201
Verdigris	11070103	Moline Reservoir	5	Eutrophication	LM071901

One new station listed as impaired for Gross Alpha. Screening: Uranium average concentration > 30 µg/L Assessment Method: Gross Alpha (Drinking Water Standard) more than one sample > 15 pCi/L over the past 10 years

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Smoky Hill-Saline	10260003	Smoky Hill River Near Gove	5	Gross Alpha	SC739

One new station listed as impaired for Total Phosphorus. Assessment Method: Aquatic Life screening, TP median concentration > 0.201 mg/L

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Solomon	10260014	Twin Creek Near Corinth	5	Total Phosphorus	SC668

New Category 4a Listings, with TMDLs:

Previously Delisted stations that go back to Cat. 4a, i.e., TMDL status

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Lower Arkansas	11030009	Rattlesnake Creek Near Hudson	4a	Chloride	SC660
Verdigris	11070102	Fall River Lake	4a	Eutrophication	LM023001

New TMDLs developed since the 2016 303(d) List Approval

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Kansas-Lower Republican	10270104	Cedar Creek Near Cedar Junction	4a	Total Phosphorus	SC252
Kansas-Lower Republican	10270104	Kansas River At Desoto	4a	Total Phosphorus	SC254
Kansas-Lower Republican	10270104	Kansas River At Eudora	4a	Total Phosphorus	SC255
Kansas-Lower Republican	10270104	Kansas River At Kansas City, Kansas	4a	Total Phosphorus	SC203
Kansas-Lower Republican	10270104	Kansas River At Lecompton	4a	Total Phosphorus	SC257
Kansas-Lower Republican	10270102	Kansas River At Wamego	4a	Total Phosphorus	SC260
Kansas-Lower Republican	10270102	Kansas River At Willard	4a	Total Phosphorus	SC259
Kansas-Lower Republican	10270101	Kansas River Near Ogden	4a	Total Phosphorus	SC518
Kansas-Lower Republican	10270104	Kill Creek At Desoto	4a	Total Phosphorus	SC253
Kansas-Lower Republican	10270104	Mill Creek Near Shawnee	4a	Total Phosphorus	SC251
Kansas-Lower Republican	10270102	Shunganunga Creek Near Topeka	4a	Total Phosphorus	SC238
Kansas-Lower Republican	10270104	Wakarusa River Near Eudora	4a	Total Phosphorus	SC500
Neosho	11070205	Bachelor Creek Near Labette	4a	Total Phosphorus	SC698
Neosho	11070207	Cow Creek Near Lawton	4a	Total Phosphorus	SC567
Neosho	11070205	Labette Creek Near Chetopa	4a	Total Phosphorus	SC571
Neosho	11070205	Labette Creek Near Labette	4a	Total Phosphorus	SC564

New Category 3 Listings:

Insufficient available data and/or information to make a use support designation. No recent data to indicate use support, water falls short of statistical impairment, or insufficient bacteria data.

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Neosho	11070205	Flat Rock Creek Near St. Paul	3	Atrazine	SC613
Upper Arkansas	11030008	Walnut Creek Near Heizer	3	Atrazine	SC597
Upper Arkansas	10260014	Carr Creek Near Cawker City	3	Atrazine	SC669
Neosho	11070203	Cottonwood River Near Emporia	3	Biology	SC274
Verdigris	11070106	Little Caney River Near Caney	3	Biology	SC574
Neosho	11070201	John Redmond Lake	3	Dissolved Oxygen	LM026001

New Category 2 Listings:

Water use was previously listed but now has water quality sufficient to support designated uses.

Basin Name	HUC 8	Waterbody Name	Category	Impairment	Station
Neosho	11070201	Four Mile Creek Near Council Grove	2	Cadmium	SC630
Marais des Cygnes	10290102	Marais Des Cygnes W.A.	2	Copper	LM053201
Missouri	10240011	Atchison Co. SFL	2	Copper	LM012601
Neosho	11070205	Neosho W.A.	2	Copper	LM053401
Kansas-Lower Republican	10270104	Coal Creek Near Sibleyville	2	Dissolved Oxygen	SC679
Lower Arkansas	11060001	Silver Creek Near Silverdale	2	Dissolved Oxygen	SC706
Missouri	10300101	Blue River Near Stanley	2	Dissolved Oxygen	SC205
Verdigris	11070103	Drum Creek Near Independence	2	Dissolved Oxygen	SC699
Smoky Hill-Saline	10260006	Smoky Hill River Near Wilson	2	Gross Alpha	SC723
Marais des Cygnes	10290102	Marais Des Cygnes W.A.	2	Lead	LM053201
Marais des Cygnes	10290101	Ottawa Creek Near Ottawa	2	Lead	SC616
Neosho	11070205	Parsons Lake	2	Lead	LM041401
Walnut	11030017	Augusta Santa Fe Lake	2	Lead	LM041601
Neosho	11070203	Cottonwood River Near Emporia	2	Nitrate	SC274
Upper Arkansas	11030001	Arkansas River At Coolidge	2	Nitrate	SC223
Lower Arkansas	11060001	Cowley Co. SFL	2	Selenium	LM013401
Missouri	10240008	Pony Creek Near Reserve	2	Selenium	SC291
Marais des Cygnes	10290102	Marais Des Cygnes Near Trading Post	2	Total Suspended Solids	SC745
Upper Arkansas	11030008	Walnut Creek Near Alexander	2	Total Suspended Solids	SC596